Concrete

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Concrete Roads and Demand for Cement

THE fact that four states in the Middle West have recently gone into the market for nearly seven million barrels of cement for their combined requirements in carrying out 1922 highway programs is expressive.

With the first advent of good weather shipments of cement were reported to be moving out of the Lehigh cement district at the rate of 100 cars daily. A large percentage of this cement will eventually find its place in concrete roads.

Sand, gravel and crushed stone are reported as advancing slightly in the East due to demands but cement prices have declined. Complaints are being made by dealers about the slowness of deliveries of these basic construction materials, especially of cement, which is further indication that other construction programs are soon to get under way.

The concrete road is not confined to America. In England rapid developments are being made in concrete road building and the concrete roads movement is being introduced slowly, but surely, in Japan. Although American road engineers, builders and enthusiasts have been responsible in a measure for some of the early developments of concrete roads in countries where the field is comparatively new, later developments have been founded upon the merits of the roads that have been built and have given satisfactory service.

Business Is Better

BUSINESS is getting better.

It would be easy to bring a mass of figures and tables and graphs as proof of this, but such demonstration is not required by those who are engaged in the construction business. They already have the proof, in the shape of new orders and contracts—instructions to proceed with work that has long been held up.

The continued easing of the money situation, the improved condition of the bond market, the relief of the unemployment situation and the gradual stabilization of prices—all these have had the effect of benefitting business in general.

The construction business, however, is a key industry. When it goes ahead it pulls a lot of other activities along with it. And the average of activity in the building business right now is well ahead of the average activity in business as a whole.

Labor is still a big controlling factor and employers are being urged to spare the whip, now that they have the advantage. There's no relief yet from high freight rates, though there is still hope. The coal strike will hurt, but is not expected to proceed far without government interference.

The general price level of all commodities, according to government figures, is still well above the 1913 average. The fact that the present level of prices for house furnishing goods is 41% above the present general price level, building materials 33% above the general price level and metal products 23% below and farm products 16% below the general price level, indicates that there is still some readjusting to be done.

The record of building activities for the last three months reads like old times. The construction field seems to be going ahead with the intent of making up for many barren years. The F. W. Dodge Co. reports that building permits issued in February showed a 50% gain over February, 1921, which was an exceptional month. January this year eclipsed January, 1921, by 125%.

The need is for residences, business buildings, public structures and highways and it is in these classes that construction shows the greatest real activity. There seems to be business ahead to keep the man power and the machine power of the whole construction industry well engaged for this year and, in fact, for four or five years to come.

Specialties and Diversified Manufacture

DIVERSIFIED manufacture is suggested as the solution of many products manufacturers' problems. Some of them have had their eggs all in one basket—silo staves, for instance, and an off year for building to a large extent among farmers. There are many standard lines worth looking into before taking a plunge into a new line of work and it is also worth while for the products man to consider and give serious study to the possibilities in making specialties—specialties perhaps of purely local significance. Here and there a manufacturer builds up a good business with some specialty of his own development.

The specialty is less apt to be hedged about by too keen a competition. To the man with an original idea to meet a common need there is the chance to get in on the ground floor, so to speak. With such a product the subsequent imitator is obviously a follower.

Several instances of successful developments of concrete specialties have been noted in these pages and a number of others are to have attention. If you have developed a specialty in your community tell us about it.

To Manufacturers of Concrete Block, Block Machines and all Products Plant Equipment and Materials.

Fire Tests

There is nothing that will give a bigger boost to the concrete block business by increasing the use of the product than tests which will establish standards of quality for such products so they will pass muster before insurance men as fireproof building units.

It will mean thousands of dollars to individual block manufacturers to establish the fact in their communities that they can make block that won't go to pieces when the wooden part of the building in which they are used goes up in flame.

Block men and block machinery men have been talking about such tests for years. But talk doesn't do the business. The American Concrete Institute has talked about it. The Concrete Products Association has talked about it, and the Portland Cement Association's technical staff has talked.

Hundreds of Block Manufacturers have written this magazine and asked what to do.

Last spring the American Concrete Institute feeling the necessity of fire test work in the Products Field appointed a Committee—designated as committee P-5—Fire Resistance of Concrete Building Units, to draw up a test program and outline the means of raising the money to pay for the tests.

Finally last year the Concrete Products Association started raising money—so far it has $1,128 in cash and $575 in pledges.

At the Institute convention in February Committee P-5 made its report outlining a test program and the Board of Direction of the Institute took action as follows:

"On motion duly made and approved, the sum of five hundred dollars ($500) was appropriated as the nucleus of a fund of about six thousand dollars ($6,000) to be known as the 'Concrete Building Units Fire Test Fund' and the Institute's Committee P-5, Fire Resistance of Concrete Building Units, authorized to solicit the additional funds necessary to pay for the tests as outlined by Committee P-5, in its report, none of the Institute's appropriation to be made available until all funds necessary for the tests are fully subscribed."

The Institute's Committee P-5 reports that the Concrete Products Association will turn over its funds to help pay for the program to be carried through by Committee P-5. The Portland Cement Association has appropriated $2,500 to help pay for the tests provided the full sum necessary, about $6,000, is raised and the tests made this year.

If you have not already contributed to the fund or if your contribution was smaller than the importance of the work justifies write your check payable to American Concrete Institute marked for "Concrete Building Units Fire Test Fund" and mail it to

Treasurer, American Concrete Institute
1809 East Grand Boulevard, Detroit, Michigan.

It has been suggested that owing to the impossibility of getting contributions soon enough from all products manufacturers who will be benefited that block manufacturers should contribute not less than $25 each and manufacturers of block machinery should contribute $100 each.

Action must be prompt so that the test program may be started at once.

Building an Outfall Sewer of Concrete at Syracuse

Much of the Story Is Told in Pictures

Extensive drainage and sewerage improvements have been under way for several years for the City of Syracuse, N. Y. The deepening of the principal water courses, the lining of the channels with concrete and the construction of the intercepting sewer systems have been largely completed. Sewage treatment works will be placed under contract during the present year. The sewage outfall extending from the site of the treatment works to deep water in Onondaga Lake was constructed last season and has been placed in service, thereby diverting the flow of sewage from the water courses and greatly improving the sanitary conditions of these streams. The subaqueous section of the outfall works, recently completed, is here described and illustrated.

The subaqueous outfall, 1,634 ft. long, is made up of 60-in. reinforced concrete pipe cast on end in 20-ft. lengths. The pipe shell has a thickness of 6 in. and is reinforced with a double ring of triangular mesh weighing 89 lbs. per 100 sq. ft. The 20 ft. lengths of pipe weigh about 13 tons each and after seasoning were turned down to a horizontal position by means of the special derrick shown in one of the pictures (Fig. 9).

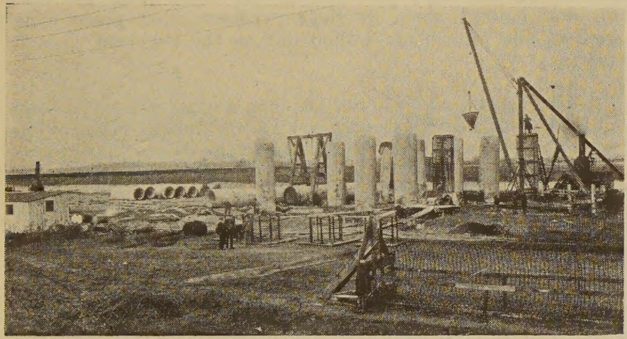


FIG. 1—GENERAL VIEW OF MANUFACTURING YARD SHOWING 60 IN. DIAMETER PIPE, 20 FT. LONG, EACH SECTION WEIGHING 13 TONS WHEN CURED

This pipe has a 6 in. wall only and one can readily see the great amount of care which had to be exercised in tamping these long lengths which contained two rings of No. 208 A. S. & W. Co., triangular mesh reinforcement through their entire lengths besides. The dark spots on the pipe are caused by the baking in or drying of the parafin in the form oil during steaming; they would disappear with the ageing of the pipe.

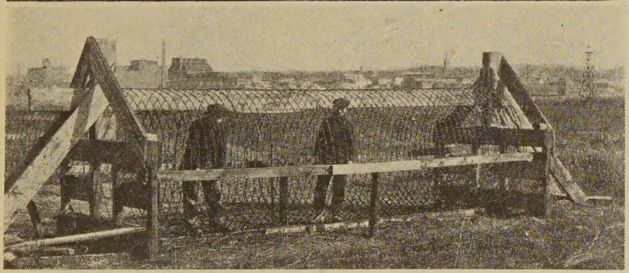


FIG. 2—FABRICATION OF REINFORCEMENT CAGES

Two to each pipe, made up of 5 sections of 4 ft. wide triangular mesh. Each cage has 6 longitudinal rods equally spaced on circumference on ½ in. deformed steel.

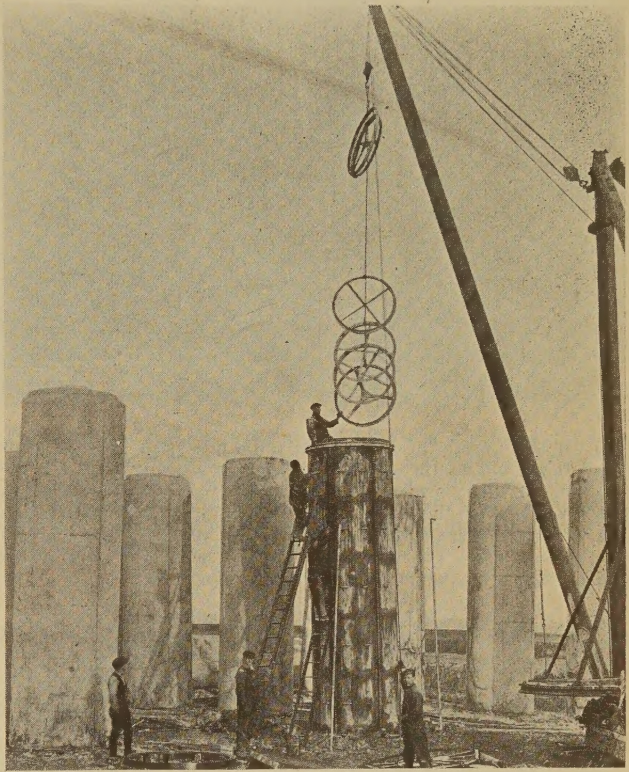


FIG. 3—TAKING OUT SIX RINGS AT ONE OPERATION

These rings are pictured fastened together at their proper distances by a chain which is also used for lifting. These rings are used for holding the inside form to its true shape and strengthen it also in its tendency to collapse. Two of these rings serve the double purpose of truing up forms and the molding of the bolt holes in the pipe wall. These molded holes take the eye-bolts which are used in jointing the pipe under water. Note the blocking under the base ring for the prevention of sinking into the ground and also the wedges used in leveling up the ring before setting forms. All pipe were kept from tipping over by undermining the high side instead of raising the low side. A mason's trowel was found to be the best tool for this purpose.

The pipe were cast with hub and spigot ends. Three galvanized iron pipe sockets, equally spaced around the circumference and 9 in. from the ends, were embedded in the pipe and attached to the reinforcement for the insertion of eye-bolts and tie rods for joining adjacent pipes.

The plant for pipe manufacture was equipped for making 2 lengths of pipe per day. The side forms were removed after 24 hours, making it necessary to provide only 4 sets of inside and outside forms. Fourteen base plates forming the hub end were furnished, as these

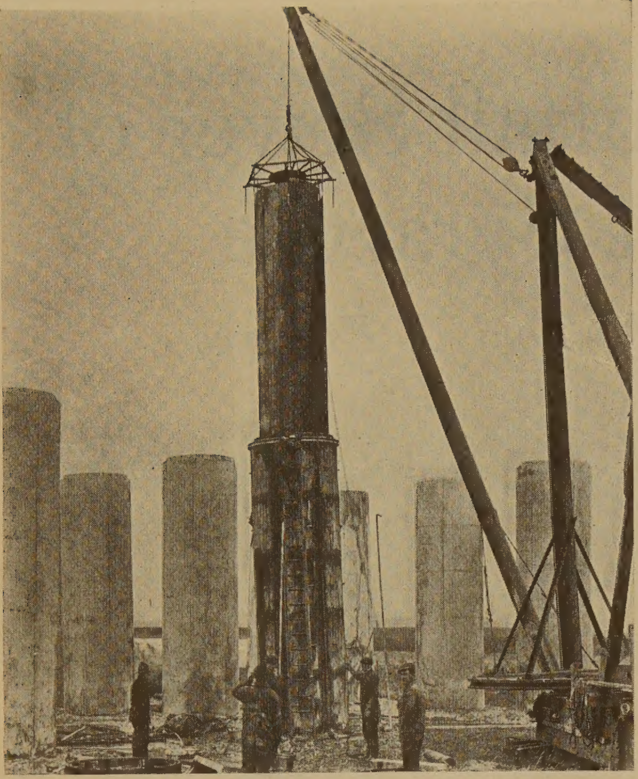


Fig. 4—Stripping Inside Steel Form by Loosening of One Sheet Only

The "spider" used for lifting will "lift up" and "lift in" this loose sheet and as the strain is afterwards brought on the remainder of the form it is contracted to a small diameter, thereby clearing the fresh concrete, and is then lifted out. All of this is entirely automatic after the spider is once hooked on to the form. The same apparatus is used for both inside and outside only that a reverse action takes place.

plates could not be released until the pipe had seasoned and been turned down.

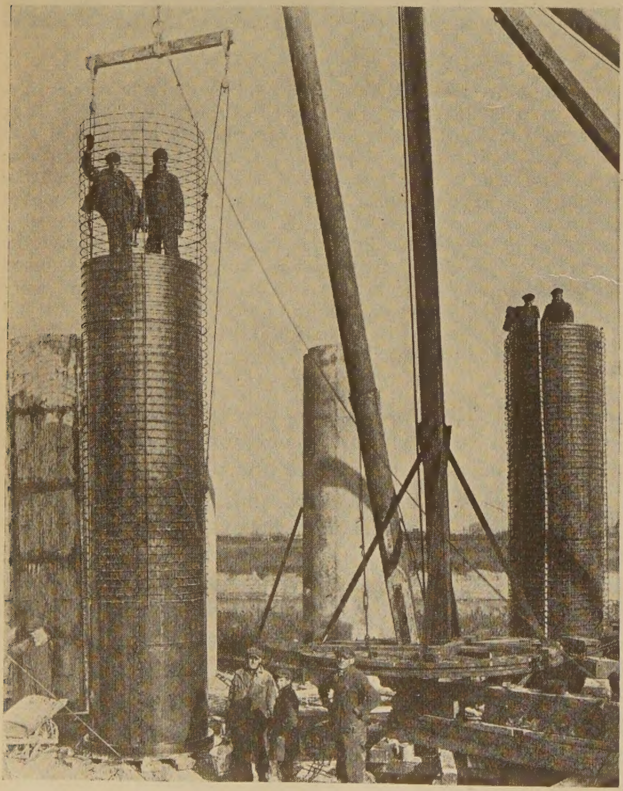
When ready to place the spigot was given a thick coat of Barrett's Elastigum. Water-tight timber bulkheads were then placed over each end and the pipe floated out in the lake, lowered to place, set and joined in position by two divers, on the special pile foundation. Little difficulty was encountered in laying from 3 to 6 lengths each day.

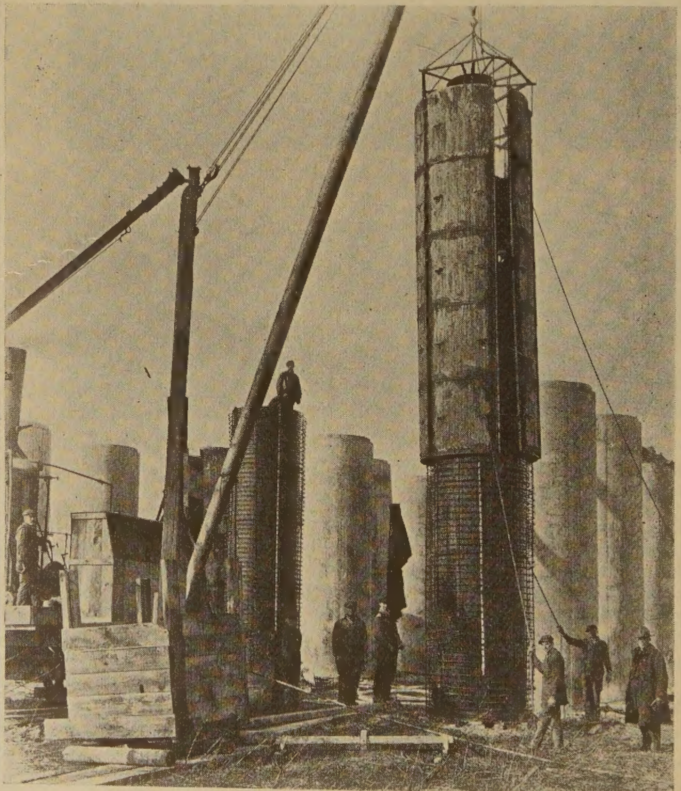
The nature of the lake bottom was such as to require a special foundation for the support of the pipe. Two piles on 5 ft. centers were capped with a 10 in. x 10 in. timber drift bolted to the pile heads. These bents were spaced 10 ft. center to center for the entire length of the outfall, except the last 20 ft. of the lake end, where the spacing was made 4 ft. This last 20 ft. of the foundation was cross-braced and surrounded with riprap as a further protection against wave action. Two pillow blocks were spiked to the timber cap to form a cradle support for the pipe and transfer the weight to the piles rather than to the cap. A 7/8 in. round rod was employed to anchor the pipe to each bent by passing over the pipe and through the ends of the timber cap. Each end of this rod was threaded and, drawing up on the nut, secured rigid attachment. All timber work with the exception of the piles was thoroughly creosoted and all exposed metal work heavily galvanized.

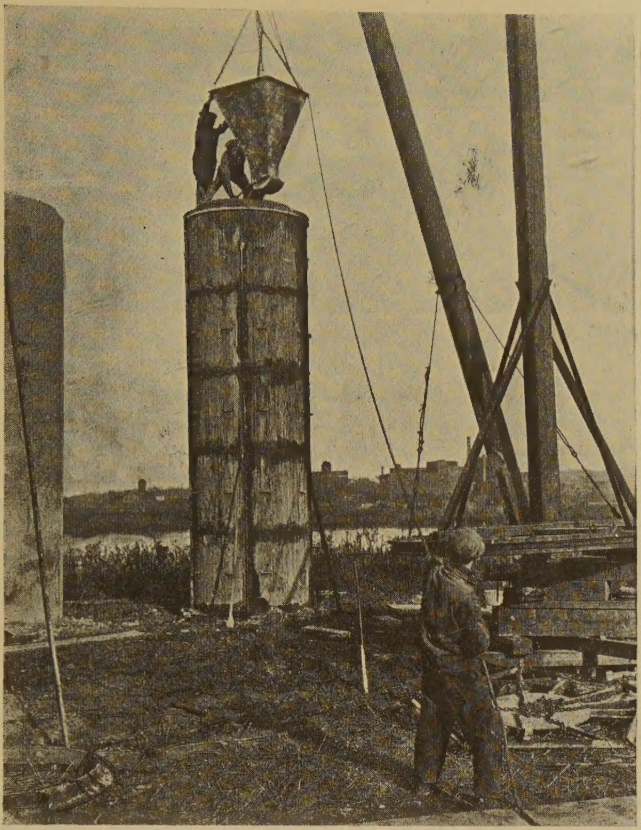
Fig. 5—(Below Left) Putting on the Inner Cage of Reinforcement with a Sort of "Walking Beam" Which Balances the Cage from the Time it is Picked up from a Horizontal Position on the Ground Until it is on the Form

To the right are seen the two cages in place; note the large pipe between the cages. These pipe are put on the outside of the inside cage to facilitate putting on the outside cage, so that the two cages do not become enmeshed. These pipe are then removed and used for spacing the cages from the steel forms and holding them at their predetermined place while concreting, the pipe being pulled out as the concrete rises in the form.

Fig. 6 (Below Right) Placing Outside Form, Showing Same "Spider" Handling Form, as was Used on Inside Form. The Outside Form is Opened Only at One Seam







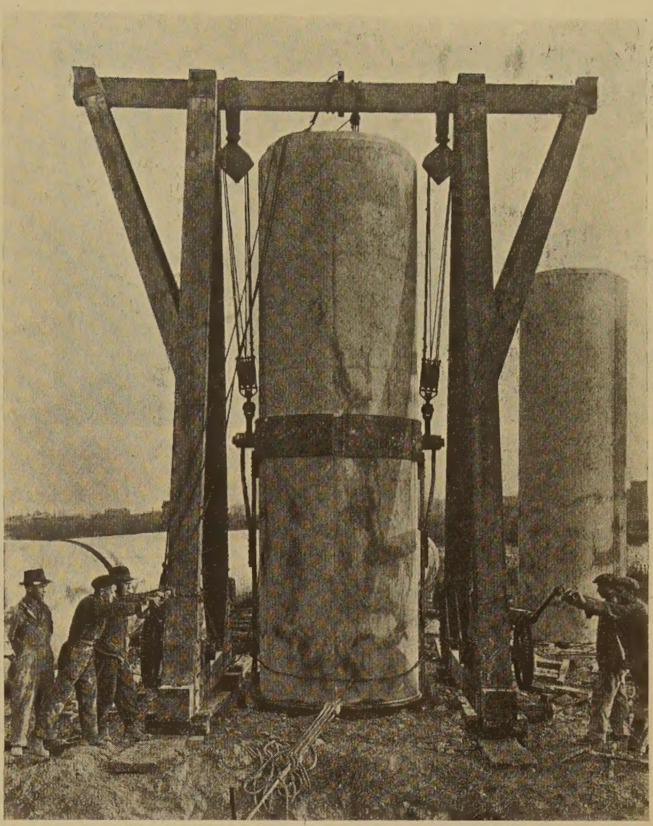


FIG. 7—POURING CONCRETE

FIG. 8—METHOD OF TIPPING GREEN PIPE

A small worm hoist was set in between the timbers and used for raising pipe 1 ft. off ground or about 6 in. of actual raising as the blocking under base ring was removed, giving the other 6 in. Four men would raise the pipe in 2 min., or less sometimes. Then one man would take out the blocks and another would overbalance the pipe by the small ½ in. block and fall shown at bottom of pipe. The other two are lowering the pipe all this time. The first two men now prepare skids for placing the pipe on the ground and also put down plank for running derrick to next pipe.

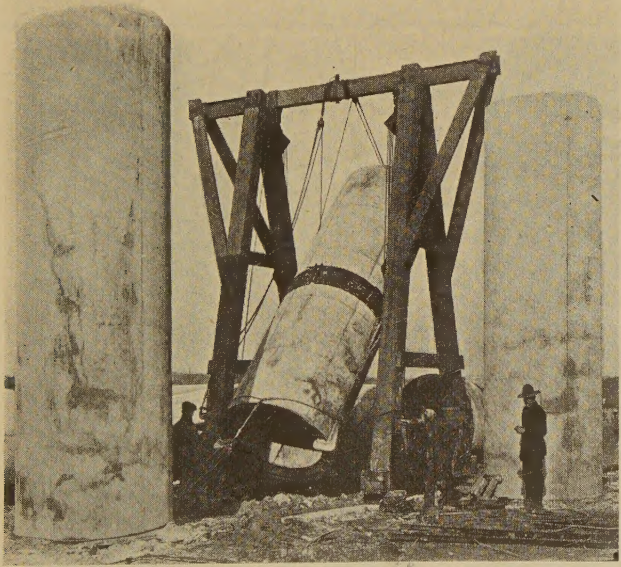


FIG. 9—THIS SHOWS PIPE TURNING OVER

These pipe were sometimes turned at an age of less than 108 hrs., and out of a total of 81 pieces, 12 were tipped over by this method at an age of less than seven days. Not a crack of any kind, was found and each one was minutely examined.

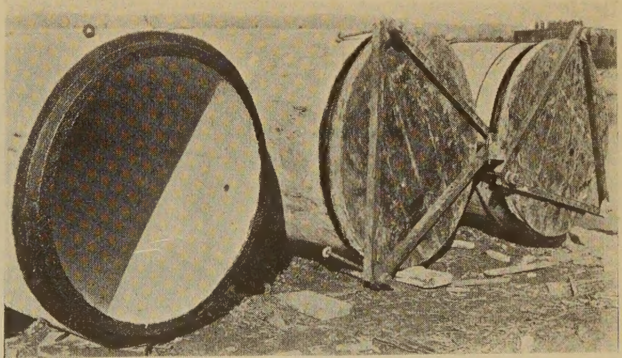


FIG. 10—BULKHEADS IN PLACE ON PIPE READY TO BE PUSHED OFF BANK

Bulkheads made of 2 in. plank and using same holes and bolts used for jointing pipe to hold bulkheads on. The black coating shown is Barrett's Elastigum and was put on, on shore, in sufficient quantity, with wicking, to do for the joint itself when lowered under water, hence the pipe was "prepared" on land, thus saving time.

The outfall was laid on a uniformly descending grade from the lake shore to the outlet end. The invert of the pipe is about 10 ft. below the normal lake level at the shore, and 22.5 ft. at the end where the depth of water was about 30 ft.

Multiple outlets were provided on the semi-diameter in the last 100 ft. of pipe and the outlet end was partly bulkheaded to insure dispersion through these outlets.

The T. A. Scott Co., New London, Conn., was awarded the contract for the construction of the subaqueous section of the outfall works, July 1, 1921, and the work was completed about December 15, 1921, under the supervision of H. L. Dunn, general superintendent. The cost of the work under itemized prices amounted to $66,489. The reinforced concrete pipe were made for the Scott Company by the United Concrete Pipe Co., of New York City, under the supervision of E. L. Peterson. The work was in charge of Girard M. Parce, Assistant Engineer. All of the work in connection with

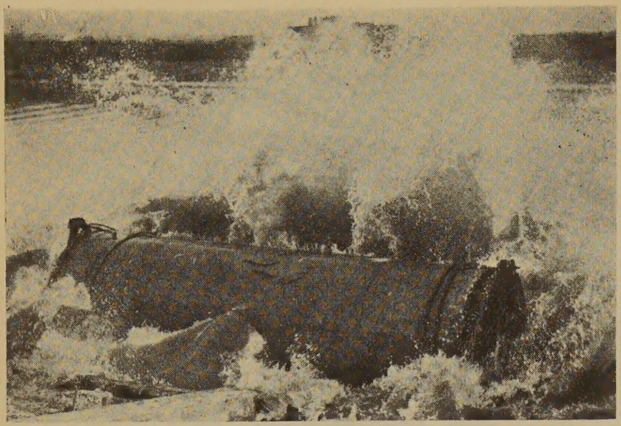


Fig. 11—"Launching" the 20-ft. Pipe Sections, To Be Floated To Place and Sunk

the improvement of the water courses, intercepting sewer system and sewage disposal are being carried out by the Syracuse Intercepting Sewer Board under direction of Glenn D. Holmes, Chief Engineer.

One of the large construction companies calls attention to the present demand for buildings by comparing the character of its present contracts with the normal character of its business:

	At Present	Normally
Straight Industrial	8%	30%
Public Utility	33	25
Railroad	8	25
Foreign	37	10
Hotels and Apartments	14	10
	100%	100%

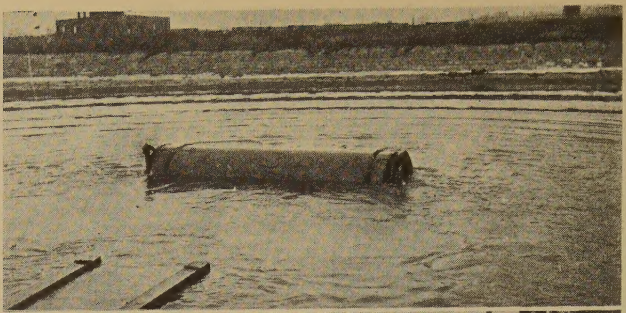


Fig. 12—Pipe After Coming To Rest. They All Floated from 18 in. to 2 ft. out of Water. The Outside Diameter was 6 ft. and Weight 13 tons, 6 in. Wall

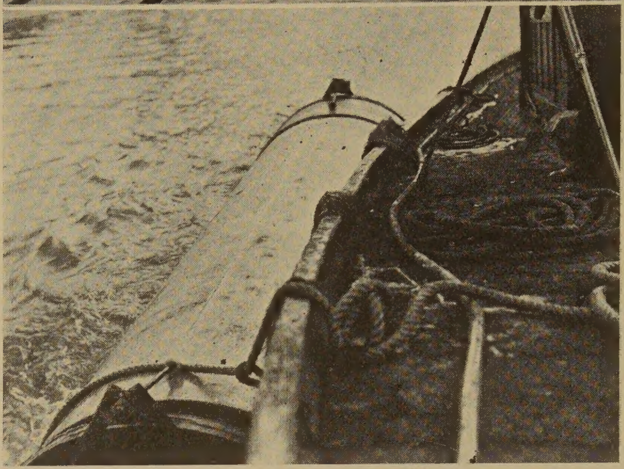


Fig. 13—Pipe Alongside of Tug Being Towed to Laying Derrick

These pipe were floating in the water as long as 1 hr. sometimes before the derrick would pick them up.

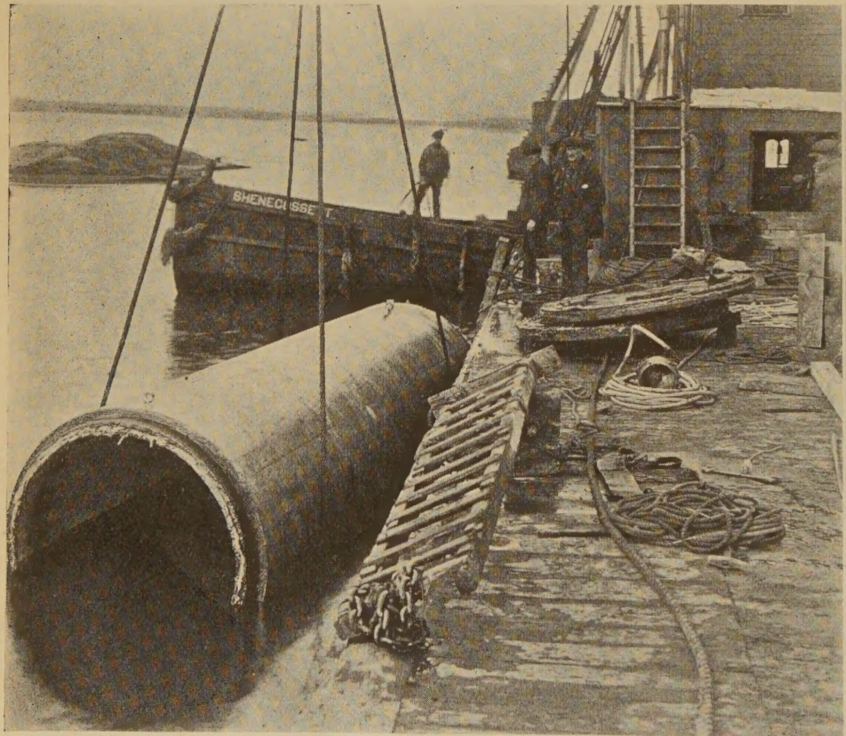


Fig. 14—Derrick Slings Around the Pipe and Bulkheads Taken Off, Ready to Lay

The pipe was never put on deck to remove the bulkheads, but were held about as shown here. Note the dryness of the concrete on the inside of the crown of the pipe, and wicking which would stick to the concrete and not to the bulkheads.

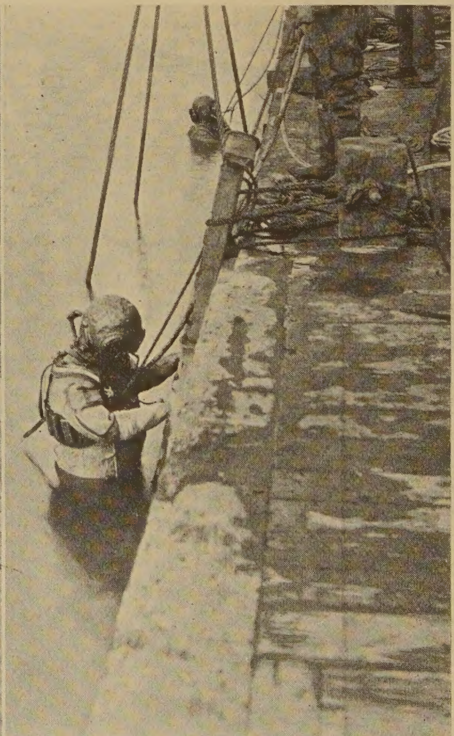


Fig. 15—Divers Going Down to Bolt Up and Lock the Pipe

One of these pipe was laid at age of 140 hrs. and out of 81 pieces 47 were less than 14 days old and not one failure nor accident. The trueness of the pipe was demonstrated by the manner in which the weight of the pipe was used in "shoving home" the spigot into the bell.

Suggested Layouts for Products Plants
—Detailed Data on Curing*

The first problem in the design of the products plant is the general layout. The local conditions, such as availability of aggregate, trackage and output, will affect the design materially, certain features of plant layout should ordinarily be incorporated, depending upon the output. Mechanical handling of the aggregates and cement into elevated bins so that gravity can be used in plant operation is desirable.

A study of plant layouts has resulted in the preparation of 7 plans, shown herewith.

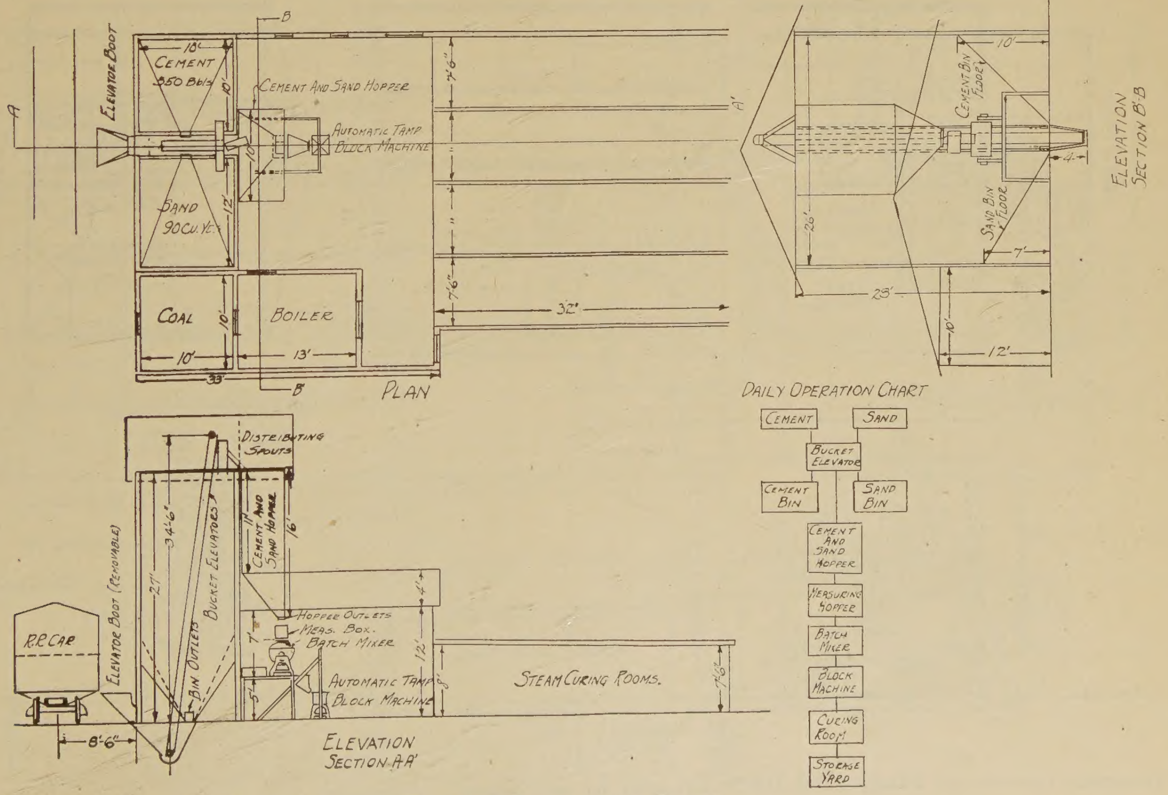
CURING

Though several methods have been suggested at various times for steam curing rooms, such as the use of steam shot into troughs of water, radiator system and water sprinkling and low pressure steam shot directly into the curing room, a scientific analysis from the standpoint of effectiveness and economy shows that steam radiation through pipes with an extra pipe equipped with controlled openings to regulate the amount of saturation in the curing room will prove most satisfactory.

Before designing the heating system, climatic conditions should be studied to arrive at the temperatures to be used. Obviously, a heating plant designed to meet the extreme conditions of time and temperature would be entirely too large for normal conditions. In a temperate climate there may be several days of winter with a temperature down to zero, or even below. The temperature of most of the winter days would be at least 32° F. It must also be kept in mind that winter conditions prevail not over three months, or 25% of the time. Mild and warm weather covers the remainder of the 75%. In warm weather the factory output should be at a maximum, and therefore the curing time should be at the minimum. It is during this time that the finished product may be required to be ready for outside storage in 24 hrs.

From the best information available, the maximum rate of absorption of heat by wet concrete in still air is approximately 1½ B. T. U. per square foot of exposed surface per degree difference in temperature per hour. Therefore, knowing the number of products in a chamber, their exposed area and the number of ponuds of concrete the total B. T. U. required to raise the product to a given temperature and the number of hours required to absorb that heat can be determined.

Another factor in the problem is the quantity of heat generated in the hardening of concrete. Although some



SUGGESTED LAYOUT FOR PLANT WITH DAILY OUTPUT OF 800 BLOCK

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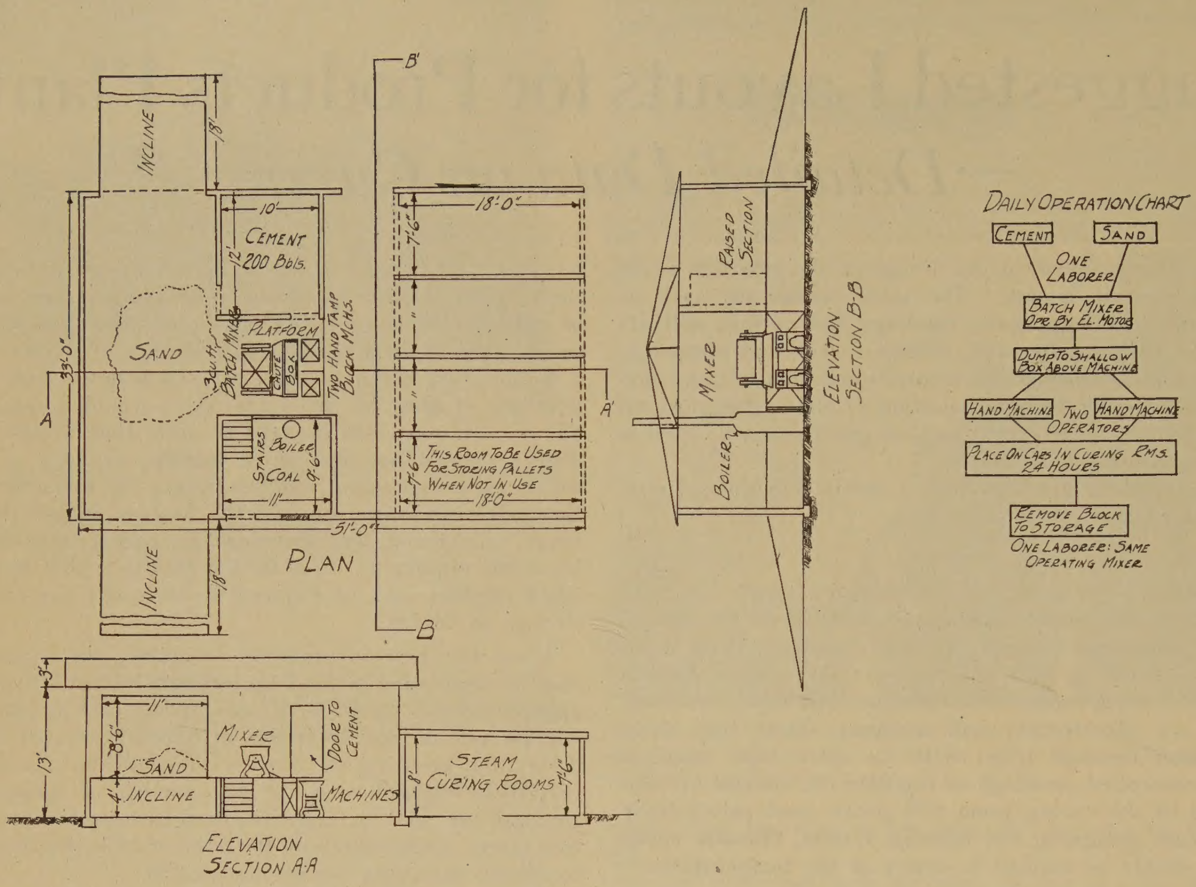
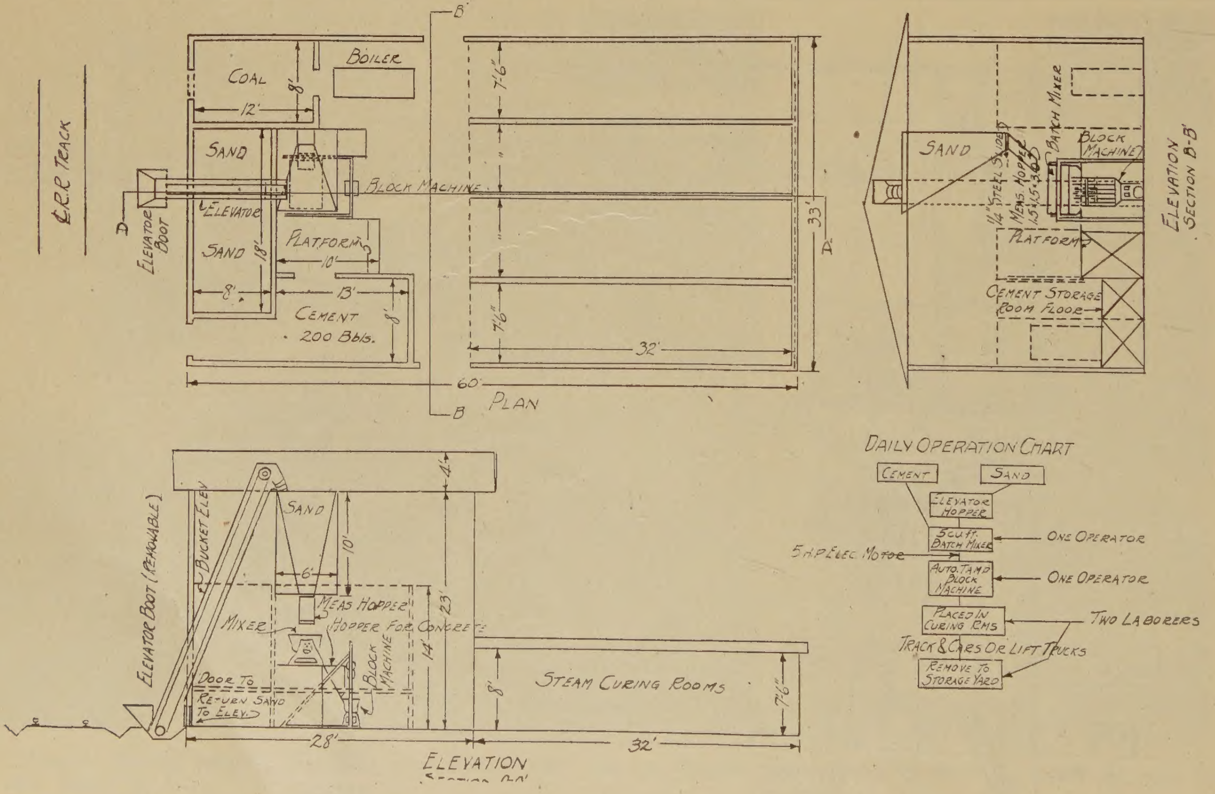
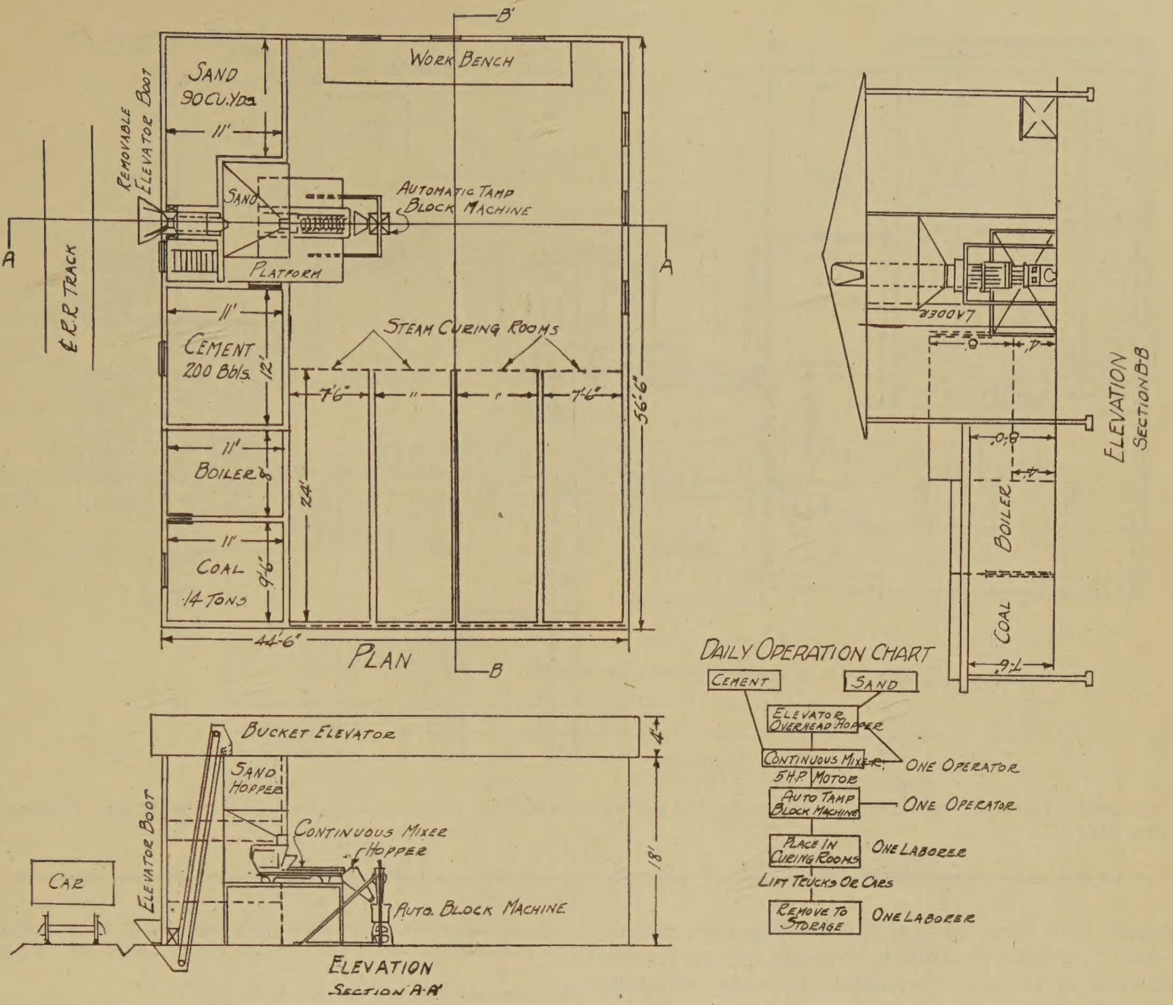
*Presenting in part the report of Committee P6—Products Plant Operation, Proceedings American Concrete Institute, Vol. 18, 1922.



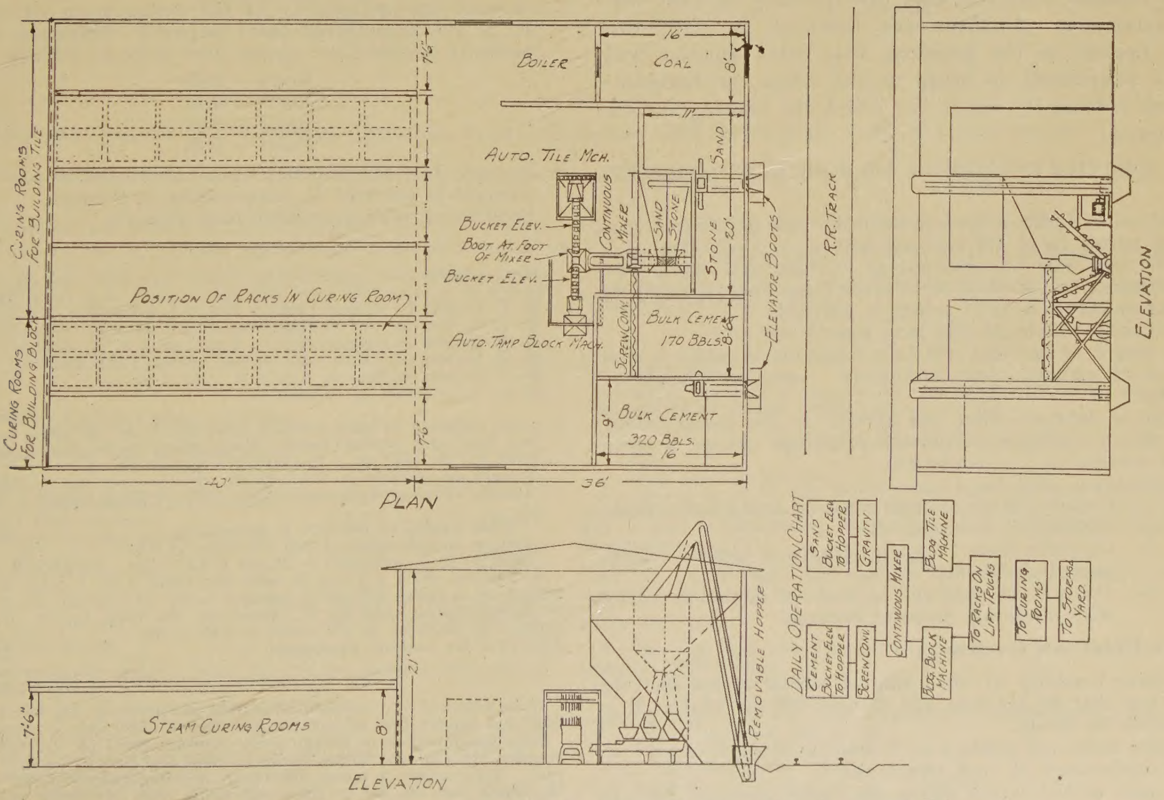
Suggested Layout for Plant with Daily Capacity of 200 to 300 Block



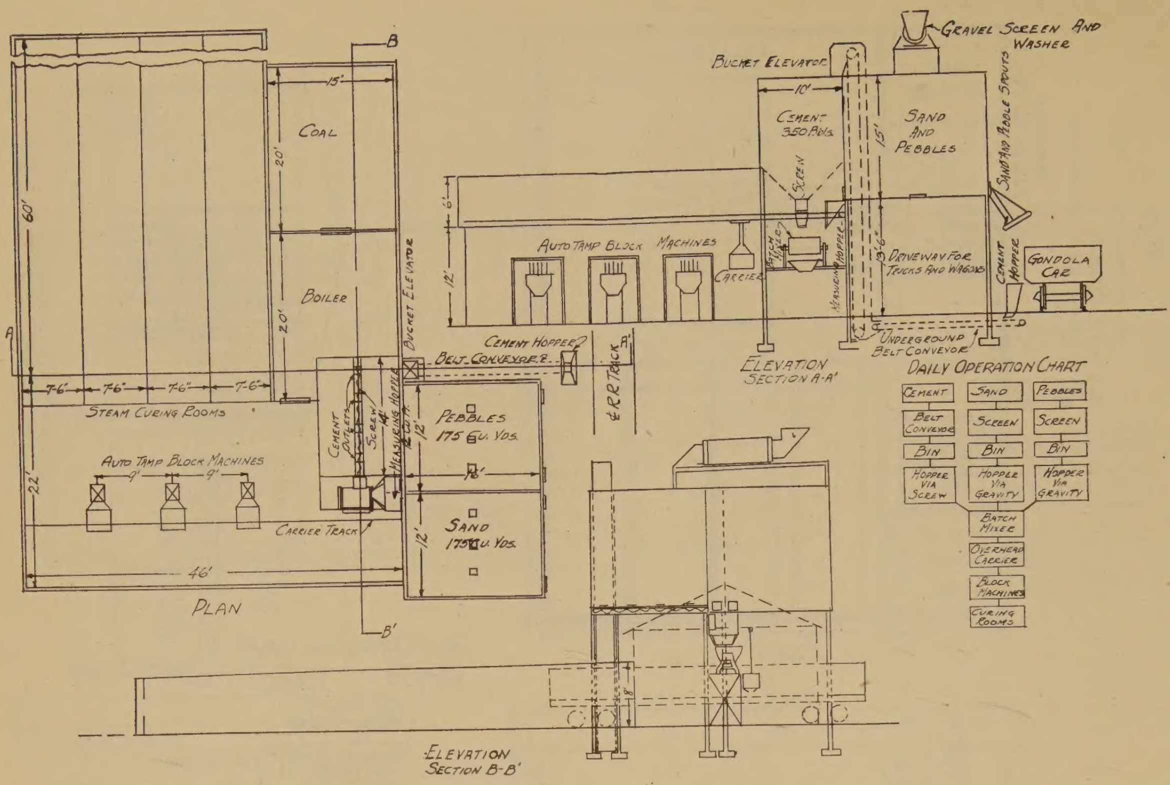
Suggested Layout for Plant with Daily Capacity of 800 Block



Suggested Layout for Plant of 800 Block Daily Capacity



Suggested Layout for Plant with Capacity of 800 Building Block—2,000 Building Tile



Suggested Layout for Concrete Products Plant with Gravel Washing Plant — Capacity 2,400 Blocks Per Day

experiments have been conducted indicating that considerable heat is given off through chemical action, results are not such as to make it possible to state definitely how many B. T. U. should be figured under ordinary operating conditions.

It is evident, however, that this quantity of heat will help materially. As there are, however, so many unknown factors in the problem, this extra amount will only be considered as being useful when the temperatures are outside the range for which the heating system is designed.

The following assumptions are made in designing the plant:

1. Production, 1,000—8 by 8 by 16 inch block per day.
2. Each curing room will hold one-half day's production.
3. Each room will be wide enough to turn and manipulate conveniently a lift truck or to place three rows of products racks or cars. A 12 ft. width is adopted.
4. Each room will be 35 feet long and 12 feet wide.
5. The height of the roof will be a minimum in which a man can work without injury to himself. Adopt wall height of 6 feet.
6. Ridge of roof at center and parallel to side walls. Slope of roof a minimum to prevent dripping. Adopt a slope 1 ft. vertical to 3 ft. horizontal.
7. Construction shall be:
    1. Concrete block or other masonry wall 8 inches thick.
    2. Substantial insulated roof.
    3. Concrete floor 5 inches thick on 6 inches of compacted cinder fill.
    4. Doors to fit tight and be made of double sheathing with insulating material between.

Assumed Operating Conditions:

1. Relative humidity of air inside of curing rooms shall be not less than 80 per cent and as near 100 per cent as it is possible to obtain.
2. Curing room and product in it shall be brought to 125° F. and maintained at that temperature.
3. In three of the curing rooms, the temperature of 125° F. should be maintained simultaneously while the fourth room is being brought to 125° F. and the fifth is being emptied and filled with products. This permits of 48 hr curing, which is desirable when the outside air is above 32° F., but still cool.
4. Assume the air outside to be 32° F.
5. Assume the air in the plant building to be 70° F.
6. Assume the temperature of the block before curing to be 65° F.
7. Assume the conductivity of the curing room structure in B. T. U's. transferred per 1 degree F. difference in temperature per hour per square foot to be as follows:

Walls —0.30
Roof —0.45
Ends —0.60
Floor —0.10

8. Assume that the product under above conditions will be brought to the 125° F. temperature in 6 hours.

Solution of heating problem is as follows:

1. Maximum Range of Temperature from 32° to 125° = 93° F.

Heat Losses:	B. T. U. per Hour
B. T. U. loss in walls = 0130 x 2 x 35 x 6.0 x 93=	11,718
B. T. U. loss in roof = 0.45 x 5 x 12.6 x 35 x 93 =	92,278
B. T. U. loss in outside ends = 0.60 x 60 x 6.7 x 93 =	22,431
B. T. U. loss in inside ends = 0.60 x 60 x 6.7 x 55 =	13,266
B. T. U. loss in floor = 0.10 x 60 x 35 x 93 =	19,530
Total	159,223

2. Heat required to raise product from 65° F. to 125° F.

500 block per curing room. Each room to be raised separately from 65° to 125°, or a temperature rise of 60° F.

Weight of concrete = 500 x 50 lbs. =	25,000 lbs.
Assume racking equipment will be 10% of block weight =	2,500 lbs.
Total weight of product to be raised	27,500 lbs.

Assume specific heat of soft concrete as 0.25

Total B. T. U. required = 27,500 x 0.25 x 60 = 412,500 B. T. U.

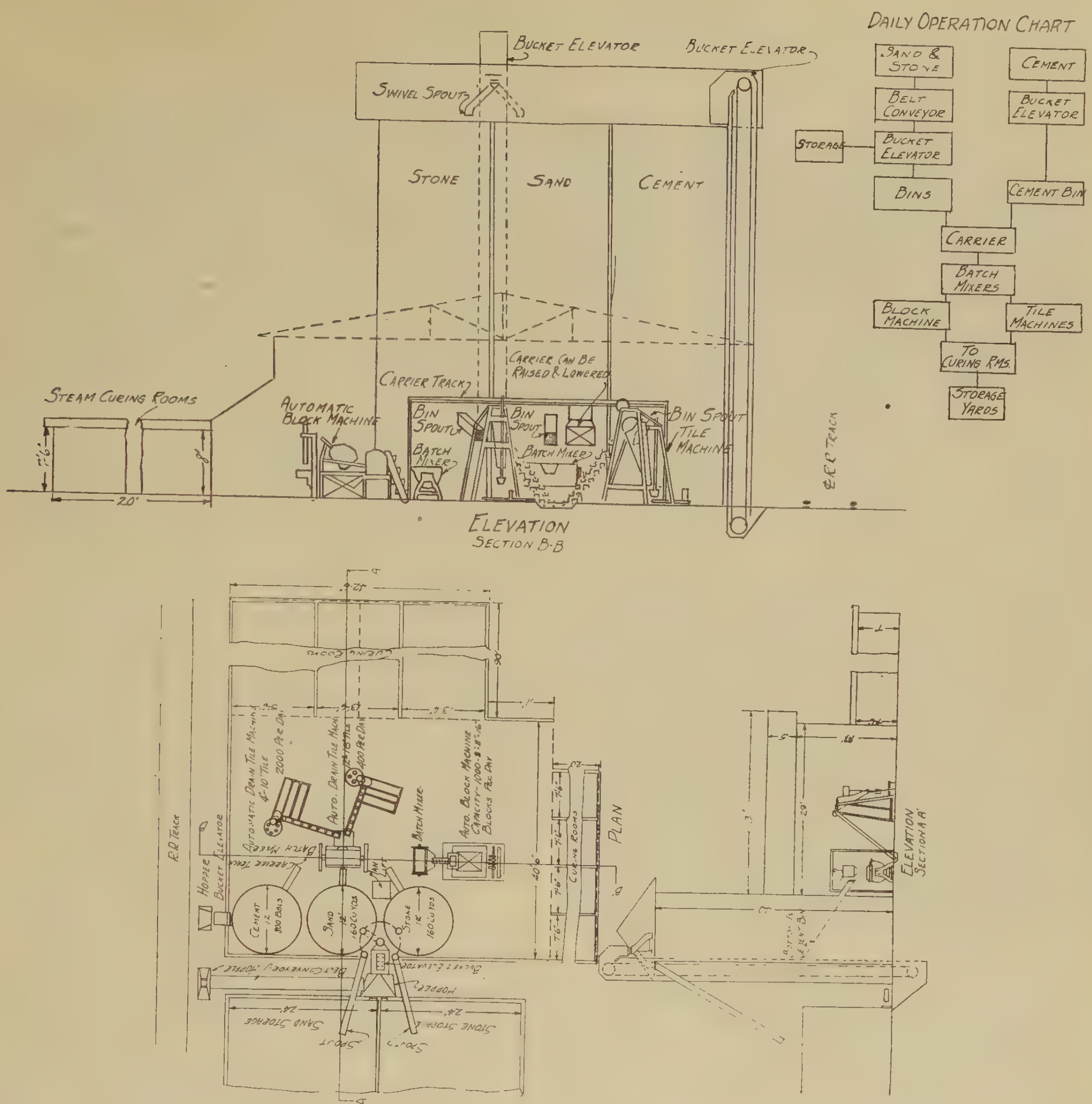
A concrete block 8 x 8 x 16 with two cores 4 in. x 5 in. in section, setting on a pallet will have exposed to the air 760 sq. in. of surface or approximately 5.28 sq. ft., therefore the total sq. ft. of exposed surface of concrete in the room = 5.28 x 500 =

surface of concrete in the room = 5.28 x 500 =	2,640 sq. ft.
Add 10% for racking equipment =	260 sq. ft.
Total	2,900 sq. ft.

It is assumed the wet concrete will absorb only 1½ B. T. U. per hour per square foot of surface per degree difference in temperature.

Also assume that in bringing the product from 65° to 125° the air reaches 125° in two hours, while it takes the product 6 hrs. to reach 125°. This means a mean difference in temperature of 20° between the block and the air in the room while both are being raised from 65° to 125°.

20 x 1.5 x 2,900 = 87,000 B. T. U. maximum that can be absorbed per hour by the product and racking equipment.



SUGGESTED LAYOUT FOR CONCRETE PRODUCTS PLANT—CAPACITY 2,400 DRAIN TILE—1,000 BUILDING BLOCK

B. T. U. required per hour = $\frac{412{,}500}{6}$ = 68,750 B. T. U.

Inasmuch as the block can absorb under these assumptions 87,000 B. T. U. per hour, it is evident that the block will be able to absorb the 68,750 B. T. U. which is given to it each hour.

To raise the air in one curing room requires:

Volume of room = 6.7 x 12 x 35 =	2,814 cu. ft.
Volume of block and racking equipment	181 cu. ft.
Volume of Air =	2,633 cu. ft.

Weight of air = 2,633 x 0.0684 = 180 lbs.
Specific heat of air = .25
B. T. U. required to raise air from 65° to 125° = 180 x 0.25 x 60 = 2,700 B. T. U.
B. T. U. required per hour for heating air = 2,700 ÷ 2 = 1,350 B. T. U.

Summation of maximum B. T. U. required:

Heat losses from rooms =	159,223 B. T. U. per Hr.
Heat required to raise products from 65° to 125° =	68,750 B. T. U. per Hr.
Heat required to raise air =	1,350 B. T. U. per Hr.
Total	229,323 B. T. U. per Hr.
Use	230,000 B. T. U. per Hr.

CALCULATION FOR BOILER

B. T. U. in steam at pressure of 10 lbs. (25 lbs. absolute pressure) = 1,160 B. T. U. per lb. of water.

$\frac{230{,}000}{1{,}160}$ = 198 lbs. of steam required per hour.

1 boiler h. p. is 34½ lbs. water evaporated from and at 212° F.
On a practical basis use 30 lbs. of water.
198 ÷ 30 = 6.6 boiler h. p. required.
Use 15 h. p. boiler.

Steam for power, heat for buildings, and for other purposes, is not included in this steam curing problem, but should be given consideration in the design of a complete products plant.

CALCULATION FOR AMOUNT OF COAL REQUIRED:

Assuming a boiler efficiency of 25%, B. T. U. required per hour = 4 x 230,000 = 920,000 B. T. U. per hour.

As each pound of coal has a theoretical B. T. U. of 11,000, coal required per hour = $\frac{920{,}000}{11{,}000}$ = 84 lbs.

SATURATION OF AIR:

9.5 lbs. of moisture is required to saturate 100 lbs. of air at 125° F.
Weight of air in one curing room = 180 lbs.

$\frac{180 \times 9.5}{100}$ = 17.1 lbs. of water required to saturate the air in a curing room at 125° F.

As 159,223 B. T. U. are required per hour for heat losses in five rooms, we can assume ⅕ or 32,000 B. T. U. per room. This figure will be used in determining whether the air in a chamber will always be saturated.

32,000 ÷ 1,160 = 27.6 lbs. of steam.

As 17.1 lbs. of steam will saturate the air, the equipment will be ample.

RADIATION SYSTEM:

Assume 2 B. T. U. per square foot of pipe per degree difference in temperature per hour.

Heat loss in outside wall:
6 x 35 x 0.3 x 93 = 5,859.0
Heat loss in inside wall when assuming the temperature in the empty chamber alongside will be 50°:
6 x 35 x 0.3 x 75 = 4,725
Heat loss outside end wall:
6.7 x 12 x .6 x 93 = 4,486.0
Heat loss inside end wall (plant at 70°)
6.7 x 12 x .6 x 55 = 2,653.0
Heat loss floor (ground at 32°)
35 x 12 x .1 x 93 = 3,906.0

Heat loss roof:

$$12.6 \times 35 \times .45 \times 93 = 18{,}456$$

$$\text{Sum} = 29{,}500 \text{ B. T. U.}$$

One square foot of radiation surface will radiate 2 B. T. U. per hour per degree difference in temperature.

$$\text{Radiation required for outside wall} = 5{,}859 + \frac{29{,}500}{2} = 20{,}610$$

$$\text{Radiation surface for outside wall} = \frac{20{,}610}{2 \times 93} = 111 \text{ sq. ft. of pipe.}$$

$$\text{Radiation for inside wall} = 4{,}725 + \frac{29{,}500}{2} = 19{,}476$$

$$\text{Radiation surface for inside wall} = \frac{19{,}476}{2 \times 93} = 105 \text{ sq. ft. of pipe.}$$

Use 1¼-in. pipe.

Each linear foot of a 1¼-in. pipe = ⅓ sq. ft. radiation surface.

Therefore, outside walls require 111 x 3 = 333 linear feet of pipe, or 10 lengths of pipe 35 ft. long.

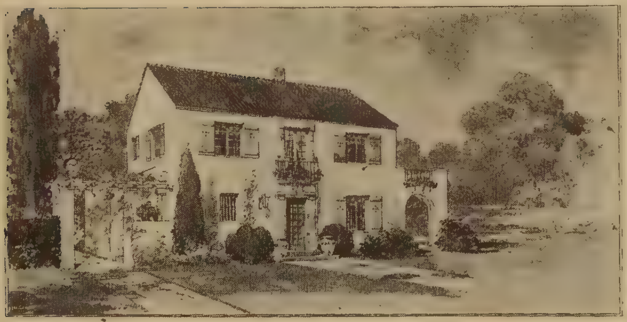
Each inside wall requires 105 x 3 = 315 linear feet of pipe, or nine lengths.

A 4-inch main line should be used from the boiler and 2-inch pipe from the main line to each room. The pipe lines should be designed with check valves so that any one of the rooms can be shut off or be in operation without affecting the other rooms. In order to provide the necessary saturation, a 1¼ inch pipe should be placed near the floor on the inner side of wall parallel with the length of the room running into a dead end. This pipe should be equipped with a spray opening or steam gauge and air cock at intervals of 3 or 4 feet. With this system, the lines of pipe should be so arranged that the piping along the outside ends will be higher than along the inside ends. This will cause the condensed steam to flow back to the main line and into the boiler.

As radiation boilers are not usually sold on a horse power basis, it is necessary to figure 10 sq. ft. of heating surface per h. p. In other words, where we require a 15 h. p. boiler, we would require a radiation boiler having 150 sq. ft. of heating surface. The smallest radiation boiler sold by a large boiler company has a heating surface of 206 sq. ft. and will supply 1600 sq. ft. of radiating surface.

In the problem above worked out, the radiating surface required is only 1,062 sq. ft.

This House a Feature of New York Own Your Home Show

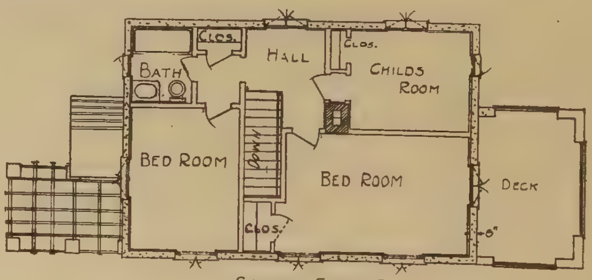


The house shown in illustrations from perspective sketch and from plans was designed by Dwight James Baum, architect, New York City, to be a feature of the Own Your Home Exposition, which is to open in the 69th Regiment Armory, New York City, April 22 to run until April 30.

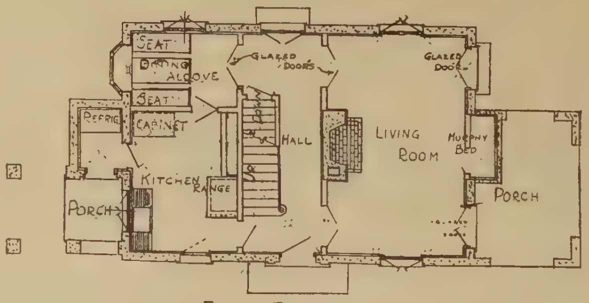
"One of the most popular types of small houses today is the straight-forward houses founded on the precedent of the small villas in northern Italy," says Mr. Baum. "These houses give the utmost space, for they are usually economical in plan with a minimum of space lost, due to simple roof construction and other ways where space is lost, as in the now popular English types.

"The detail is usually very simple, the amount of ornament is cut down to a minimum and the structural members can be simplified because of these straight lines and roof construction. On account of the foregoing the Italian type was the one selected as best suited to the desires of the committees co-operating on the building of the beautiful home convenient.

"The exterior is to be of creamy pink stucco, with an entrance feature of artificial stone made to represent the warm colored Italian travertine stone. Over the main entrance there is a simple iron railing forming a small balcony from the owner's bed room. This can be made most attractive by setting red flower pots in this space with geraniums and English ivy planted in them. All of the trim of the house, as the window frames, the wood spindle grille and the gateway, is to be painted a greyish apple green. The heavy shutters will be painted a purplish blue, giving a couple of interesting spots of color to the simple elevations. At the end of the house, the porch continues as part of the main building, with concealed flower boxes back of the simple parapet wall. Here geraniums and English ivy also give a color touch to the straight elevation. The vines falling down break up the otherwise severe line of the top. The roof is to be of red and brown tiles slightly irregular in both color and texture."



SECOND FLOOR PLAN



FIRST FLOOR PLAN

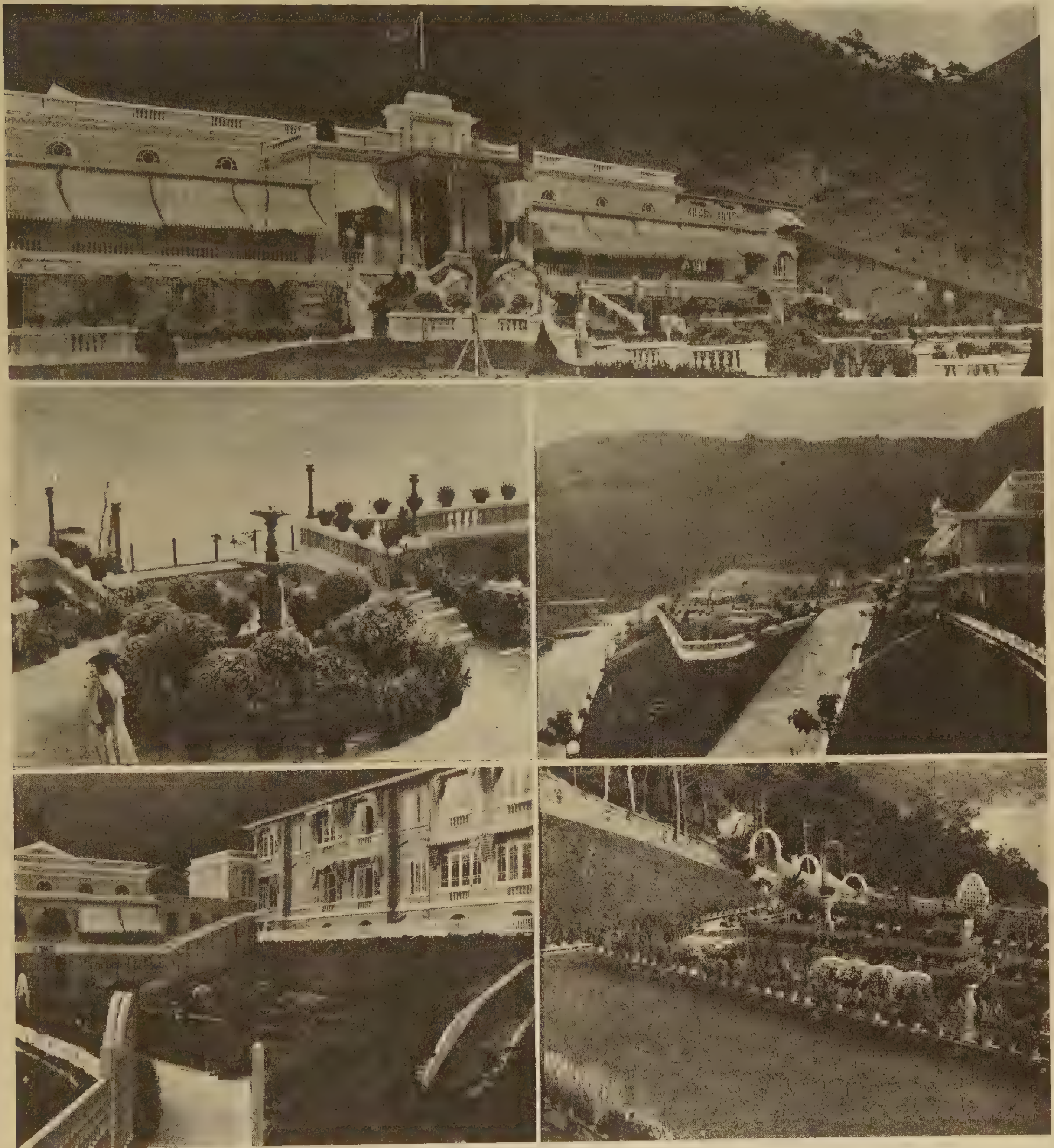
Cleveland Building Show

The American Building Exposition which has been twice postponed because of the incompletion of the new municipal auditorium, Cleveland, Ohio, will open that building April 22 in a building show to last eleven days showing every type of building material, furnishings, equipment and devices to build and equip the modern house.

The show is on a co-operative basis and the net earnings will be rebated to the exhibitors by the Builders' Exchange of Cleveland which is sponsoring it.

New Hong Kong Hotel of Reinforced Concrete—

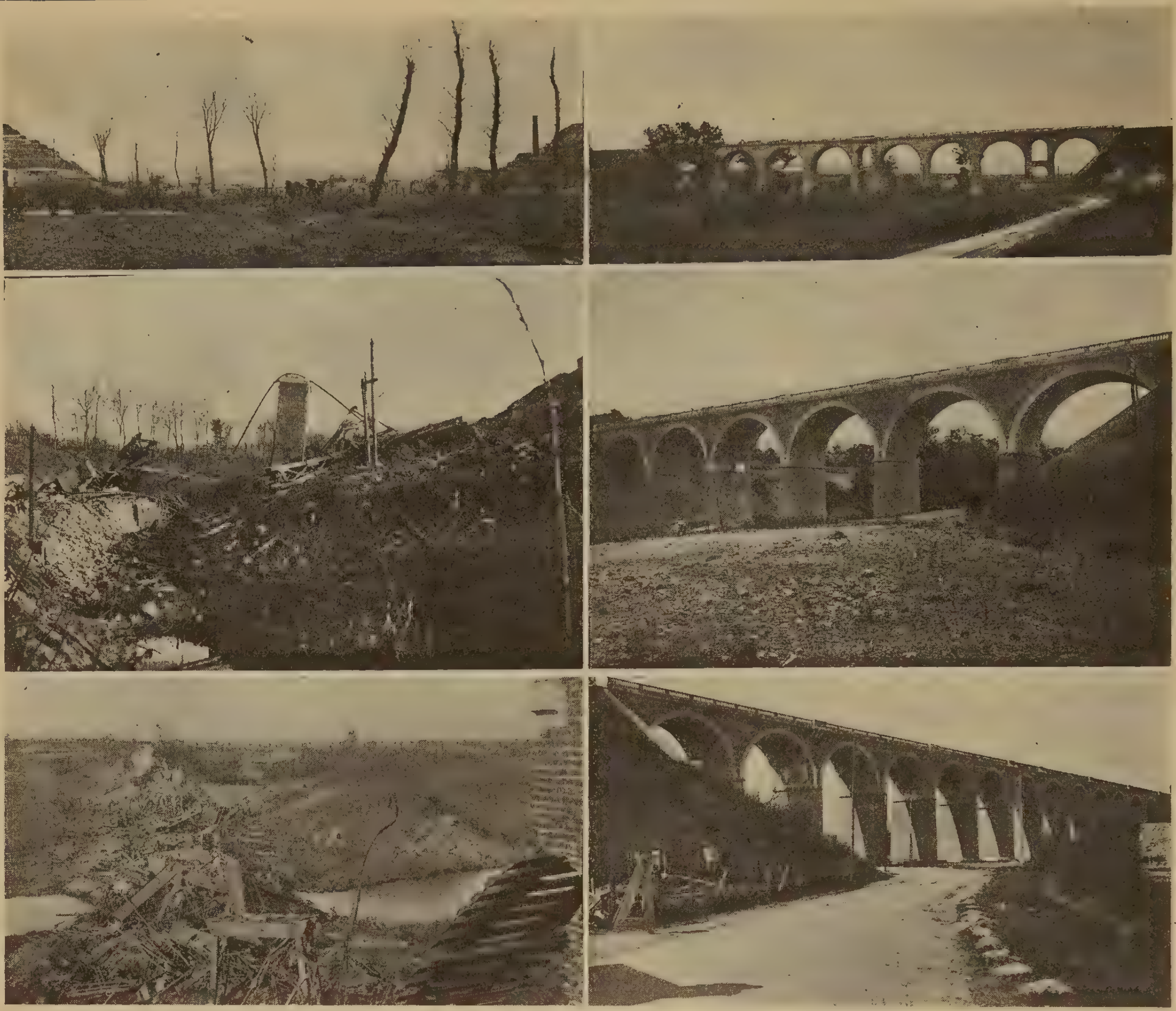
Concrete Trim Stone, Stucco and Concrete Roof Tile



A Reinforced Concrete Hotel Near Hong Kong, China —Stucco Finished—Trim of Precast Concrete Stone Made with White Cement and Crushed Marble

These pictures are of the partly built Repulse Bay Hotel of the Hong Kong Hotel Co., 18 miles from Hong Kong, China. The Chinese Government built a special concrete road through the mountains to this hotel due to the efforts of James H. Taggart, the managing director of the Hong Kong Hotel Co., who is responsible for this up-to-the-minute concrete building.

The picture at the top of the group shows the main entrance to the hotel. The buildings are of reinforced concrete, stuccoed, and the ornamental stone work, pilasters and so on are of precast stone, composed of white cement and marble dust. The roofs of these buildings are of red concrete roofing tile. The labor used in the construction has been Chinese coolies, which makes it all the more remarkable. The hotel is built on the side of a mountain and one of the ovens is a part of the terrace which overlooks Repulse Bay. James H. Taggart is shown close by the beautifully constructed concrete fountain. The terrace, garage and the winding concrete road around the mountain, and the hotel gardens showing the thousands of potted flowers, are also illustrated. Two more sections are being added to this hotel. Concrete is indebted for these pictures to Harry S. Walker, New York City.



Figs. 1 and 2—(Right and Left Top)—Saint-Penin Viaduct, 570 Ft. Long, As the War Left It and As Reconstructed in 120 Days.
After the ruins of the old bridge had been dynamited, over 21,000 cu. yds. of stone-ruins had to be removed.
Figs 3 and 4—(Right and Left Center)—Blangy Viaduct, on the Valenciennes-Aulnoye-Hirson Line, in Ruins and As Completed in August, 1919.
The reconstruction offered particular difficulties on account of the enormous mass of masonry and metal ruins, necessitating the use of dynamite and oxygen torches.
Figs. 5 and 6—The Immense Ohis Viaduct, on the Douai-Cambrai-Pusigny-Hirson Line, In Ruins and as Rebuilt by December 10, 1919.

Reconstruction in France

By Henry J. Harms
Associate Editor of "Concrete"
Courbeboie, France

The reconstruction of Northern France goes slow, extremely slow, especially as far as the building of permanent homes is concerned. Most of the houses built have been and are still, temporary affairs, most of them fire-traps and quite a few of them barely weatherproof. When this situation will change, and how it will change, I don't know, but as long as politics, syndicates, trusts of workmen, etc., are allowed to interfere with rebuilding, just so long will building remain at a standstill.

At the same time, an amazing amount of reconstruction has been done by the railroads and by industrial firms and in order to give a true history of what had to be done, of the damages wrought, and also of what is done already, the Societe des Ingenieurs Civils de France has made, this year, a thorough study of the question. The several industries had been grouped in categories, and committees appointed to write an extensive report on each group.

One of the interesting groups is the one, dealing with Transportation, reported A. E. Moutier, engineer, Assistant-Chief of Exploitation of the Northern France Railroad. The figures and facts, given by Mr. Moutier (in March, 1921) are impressive. Mr. Moutier gave me the photos from which the accompanying illustrations are made, telling the story at a glance. It will be noticed, that some work has been done at great speed, breaking anyhow all European records. For the railroads, the destruction comprised:

For the Northern Road, 1020 miles of main-track, several ten thousands of miles of secondary and accessory lines, 811 bridges, 8 large viaducts, 5 tunnels, 338 stations and 115 water-supply stations.

For the Eastern Road, 580 miles of main lines, 202 stone or concrete bridges of which 17 were of from 230 to 400 ft. span, 162 steel bridges and 10 subterranean passages.

In March of 1921 more than 6200 miles of track and 1500 new installations (stations, depots, etc.) had been

Figs. 7 and 8—Remains of the Fontaine-les-Clercs at the War—(Left) and as Rebuilt in Three Months.

rebuilt and some remarkable records of speed had been established.

A tunnel at Marseille-en-Beauvais, 1187 ft. long, with miners as laborers, and for the construction of which 100 days were allowed, was completely finished in 77 days.

A new double-track line, from Feuquieres to Broquiers, 55 miles long and crossing 3 main-lines and also the River Somme, necessitated the removal of 1,000,000 cu. yds. of earth and the use of 350,000 cu. yds. of ballast, the placing of 20 miles accessory tracks, was completely finished, ready for service, with complete block-signal systems, etc., in 114 days. We will also cite the building of a line, by the Eastern Road, between Cyperly, near Chalons-sur-Marne and Saint-Menehould (well known to the A. E. F.), in 1915. This line of 23 miles long, was completed in less than three months.

As to some record work done since the Armistice note the three pairs of viaduct illustrations.

The railroad companies have not been contented, especially, for the more important station, simply to reconstruct, blindly copying the old drawings and making the new work exact duplicates, but they have profited by the chance, offered them, that nothing was left but bare ground. Wherever necessary, they have therefore made entirely new plans, embodying all latest ideas.

Summarizing these:

Roads and Highways—44,000 miles of roads were destroyed, representing 17 million cu. yds. of road materials and 100 million cobble stones. Further a few thousand bridges and culverts, etc., among which 2000 of over 10 ft. span. In March 1921, there had been reconstructed 6200 miles of roads, and 18,000 had been repaired, while 380 bridges were rebuilt.

Waterways—640 miles of waterways were destroyed, of which 960 had been rebuilt in January, 1921, also 1120 large and small bridges, single and double sluices or gateways, of which 914 had been reconstructed at that date. The double gateway of Fontaine-les-Clercs, was rebuilt entirely within three months time. (Figs. 7 and 8.)

Splendid work has also been done by the various Mining companies, both as to the reconstruction of their mines and as to the housing of the miners. And a great effort crowned with magnificent results has been accomplished by the textile industries.

Around those industrial centers, everything is humming and the new houses with their gardens, the well laid out garden-cities make a most pleasing effect. As to the farmers, quite a lot of them still live in caves and dug-outs, and most of them have to be contented with barracks. The greater part of the ruined cities offer still a desolating view of ruins—interesting for sightseers, maybe—but otherwise deplorably sad.

And yet, some people seem to wonder why it is that it is still difficult for France to forgive, and more difficult still to forget.

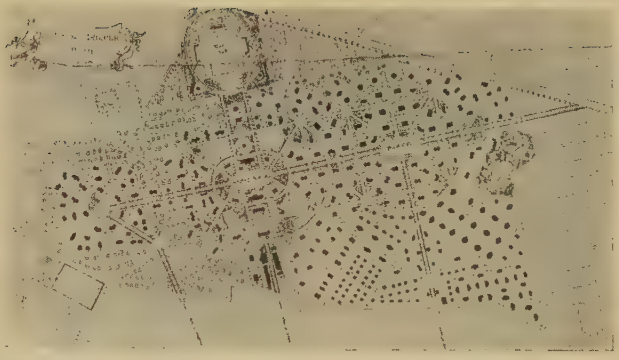


Fig. 1—Plan of City of Tergnier, France.

Concrete Block Houses in France

By Henry J. Harms

Compagnie des Chenin de Fer du Nord, generally called the Nord here, and one of the five big railroads of France, has inaugurated, assisted by the Minister of Public Works, the new City of Tergnier, with more than 1000 houses, most of them of cinder block.

This company started to make trials, timidly, on a small scale, as far back as 1883, by building homes for its workmen, at various points along its lines, where housing facilities were insufficient. At that time, for instance, a city of 35 homes was built at Bourget, which group was increased in 1888 with 52 units. Similar groups were put up at various points, in 1914, a great number of which were provided with important schooling facilities, the company building the schools and furnishing the necessary supplies, also the housing of the teachers-in-charge, sent there by the Government.

The largest part of these cities were destroyed by the enemy during the war; further, through the war, housing problems arose in districts where local resources had been sufficient before this. The problem, facing the company after the Armistice, was to enable a whole army of workmen to live in a deserted region, and to bring as quickly as possible family life to all of its employees.

Necessity to act quickly did not permit great time to be taken for the preparation and thorough study of all details, the question was to satisfy the first needs as quickly as possible, and in 1918-1919 buildings sprang up at all centers of work—wooden structures, put up by all available means at hand, like during the war. From March, 1919, until July, 1920, 3900 other houses were built by the company, still wooden structures, but of a better class already, although hurriedly prepared

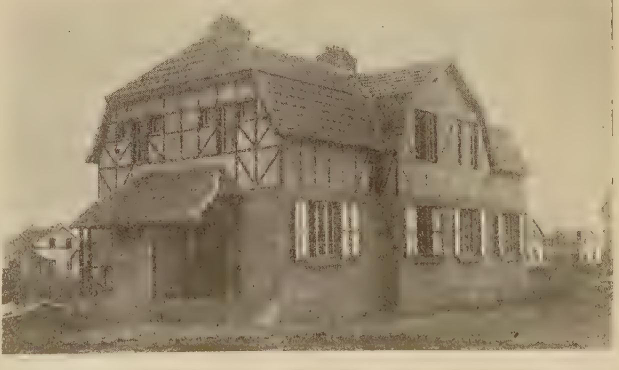


Fig. 2—Four Family House at Tergnier, France, Built of Cinder Block

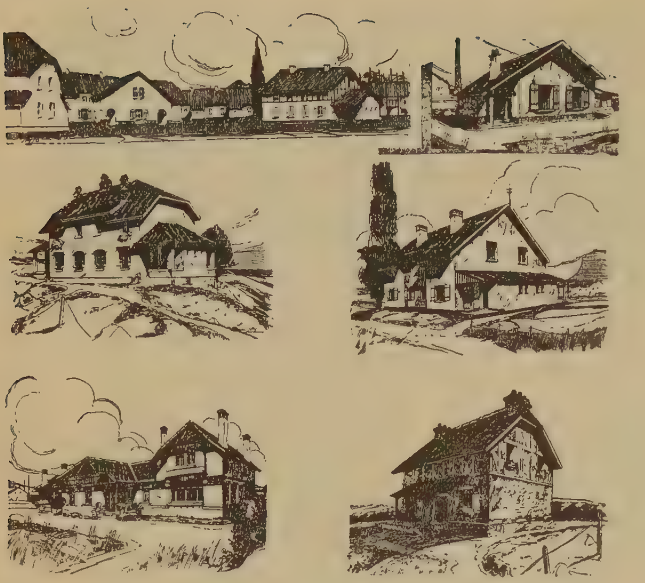


Fig. 3—Types of Cinder Block Houses at Tergnier, France.

and put up. Most of these were 3 and 4-room dwellings; living-room, and 2 or 3 bed-rooms. The houses were generally electrically lighted.

Nevertheless, these provisory constructions, although having given excellent satisfaction, could not put aside the solution of the problem of definite habitations. Consequently, a decision was taken in July, 1919, to start building homes of a durable character and an order was placed for permanent houses, work to begin at once at Tergnier and Ailly-sur-Noye. Building was pushed in an active manner and in July last, 2600 of these houses were finished or partly so, which brings the total number of these houses at the disposal of the company up to 6000. Most of the new houses are constructed of cinder-blocks, coated with hydraulic lime.

Construction of these permanent homes was given out to 25 contractors, each one to furnish from 3 to 4 different models. The normal dwelling has 4 rooms, porch, cellar, pantry, water-closet and septic tank of 200 cubic feet. Five and six-room dwellings are provided for large families.

Actual average cost price is 30,000 francs, viz., 25,000 for the building and 5,000 francs for the lot, installation of gas and electricity and building of roads.

Most of these houses are grouped in cities, four of which contain from 50 to 95 houses, seven from 100 to 195, nine from 200 to 400, five from 400 to 800 and one of 1336 houses the city of Tergnier. Further scattered in smaller cities and isolated, 225 houses, bringing the total up to 11,000. Some of these cities form, as will be noted, regular suburbs; the city of Tergnier, for instance, will have nearly 8000 inhabitants.

The City of Tergnier, inaugurated on July 10th, as stated above, leaves the well-known images of the old-style workmen's city far behind. The houses are dispersed, as in a haphazard way, amidst gardens—nothing is left of the deplorable monotony of the ugly brick match-boxes of the olden times. Large avenues between the houses, radiating from vast "places" or winding around public parks, artistically laid out with artificial hills, winding river and lakes. As to the houses, all of different model, and adapted, as much as possible, to the habits and tastes of its future inhabitants. No complicated ornamentations, but simple lines and simple decorative features to make the people feel happy—and make them love their home.

Concrete News From Germany

By C. A. Heise
Special Correspondent "Concrete"
Berlin

A Glazing for Concrete

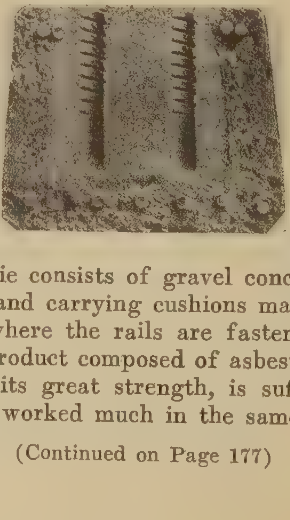
A Breslau (Germany) engineer has invented and developed a method of covering cement with a glazing by a cold process which has already been patented in several states. Up to now it was impossible to glaze over cement as it does not stand the heat incident to such process. The chief advantage claimed for the new process is the total saving in fuel so that factories for production may be erected wherever the raw materials for cement are obtainable irrespective of the presence of coal. The glazing can be carried out in any color and applied to all sorts of tiles and slabs from the roof down to the bathroom. Factories for the exploitation of this process are being established at Innsbruck, Breslau, Vienna, Pressburg, and other towns. The products will be marketed under the name of Kerament.

Concrete Sewers

Erosion of concrete sewage pipes, says *Muehlen und Speicherbau* (Mill and Store Building), has frequently been noted whenever and wherever the concrete was lacking the required components imperative to acid resistance. On the other hand, it is a fact that thousands of miles of cement and concrete piping have given very satisfactory service in the majority of German towns. This apparent paradox is now finding a ready explanation by the results of several years' observation and investigation. It was noticed that newly-laid pipes in the course of time were being covered with a fine layer of mud which proved a protective agent against the reaction of weak acid drain water. Care should therefore be taken to arrange for a dilution wherever strong acid water is flowing into the sewage culverts.

Concrete Railway Ties

Several years before the war, series of experiments were conducted with a view to ascertaining the relative merits and serviceableness in general of the Asbeston railroad tie. These experiments are now being continued.



The Asbeston tie consists of gravel concrete reinforced by round bars and carrying cushions made of Asbeston at the points where the rails are fastened to the ties. Asbeston is a product composed of asbestos and cement, which, despite its great strength, is sufficiently elastic that it may be worked much in the same way as hard-

(Continued on Page 177)

Selection of Aggregate for Concrete Roads[1]

By Duff A. Abrams
Professor in Charge Structural Materials Research Laboratory
Lewis Institute, Chicago

Introduction

The widespread use of concrete in road construction is one of the most remarkable developments in recent years. The severe service to which such concrete is subjected has given rise to much experimental work in an effort to determine the materials and methods of construction which give the best results.

The aggregate comprises about 80% to 85% of the volume of concrete; consequently, this type of material is of considerable interest to all who are engaged in concrete road construction. On account of the great weight and the consequent expense of shipping long distances, it is essential that aggregates near at hand be used if they are at all suitable. The preparation of proper specifications and methods of testing are somewhat complicated by the almost endless variety of materials available. The requirements to be met must be dictated to a certain degree by economic considerations and by local conditions. Many researches both in the field and in the laboratory have been carried out during the past few months, or are now under way, which throw much light on the proper requirements for aggregates for concrete roads.

General Requirements

Aggregate has been defined as follows: "Inert material which is mixed with portland cement and water to produce concrete; in general aggregate consists of sand, pebbles, gravel, crushed stone, or similar materials."[2]

Aggregate for concrete road construction must be clean, structurally sound, and inert in the presence of cement and water; they must possess also a certain quality which we may term weather-resistance. The division of aggregate into fine and coarse is largely arbitrary, but should be preserved as a means of securing uniformity of grading in successive batches of concrete. A wide variety in size and grading may be used with good results.

The fine aggregate is generally required to pass a ¼-in. sieve; in some instances certain requirements for smaller sieves are included. Mortar strength tests are generally required.

Aggregate Tests

Tests of concrete aggregates are made for two distinct purposes:

(1) To establish underlying principles, and
(2) To determine whether a given sample conforms to certain predetermined standards.

The two purposes in testing mark the distinction between *research* and *inspection*. The adequacy of the tests made in inspecting concrete aggregates is dependent upon the correctness of the principles established by research.

Tests of aggregates have been undergoing marked changes during the past few years. The earliest tests of coarse aggregates were adapted directly from those made on rocks for macadam roads. Experience has shown that the tests for hardness, toughness and cementation value are of little value in judging the quality of an aggregate for concrete.

It is unfortunate that standard specifications and tests for concrete aggregates have not thus far been generally adopted. The American Society for Testing Materials, the Bureau of Public Roads, and other organizations have done much toward standardization, but much remains to be done. In the absence of generally accepted standard tests, I can probably do no better than to describe the tests now made on aggregates at the Structural Materials Research Laboratory, Lewis Institute, Chicago.

Several thousand samples of aggregates from many sections of the United States, Canada, and Cuba have been subjected to test during the past seven years. Many samples were furnished by engineers or contractors from concrete road jobs; others were collected especially for research purposes. A considerable portion of our research work has been devoted to determining the underlying principles involved in the use of aggregates of different types in concrete road construction.[3] The methods of the American Society for Testing Materials have been followed where such methods have been adopted. It should be noted, however, that in many instances the A. S. T. M. methods have only recently been published as tentative standards and consequently they have not come into general use.

Fine aggregates are subjected to the following tests:

(1) Sieve Analysis—Per cent coarser than sieves Nos. 100, 50, 30, 16, 8, and 4. (Follow A. S. T. M. Tentative Test for Sieve Analysis for Aggregate for Concrete, 1921.)

(2) Organic Impurities in Sand—Digest sample in 3% solution of sodium hydroxide, observe color after 24 hrs. (Follow A. S. T. M. Tentative Method of Test for Organic Impurities in Sands for Concrete.)

(3) Silt—Loss of weight of 500-gram sample, due to washing in shallow pan and rejecting wash water. (Follow A. S. T. M. Standard Method for Test for Quantity of Clay and Silt in Sand.)

(4) Mortar Strength—Compression tests of 2 in. by 4 in. mortar cylinders at ages of 7 and 28 days, using 1:3 mix by *weight* and by *volume*. Make parallel tests on 1:3 Standard sand and mortar. (Follow A. S. T. M. Tentative Test for Compressive Strength of Portland Cement Mortars.)

(5) Unit Weight—Puddle into 1/10 cu. ft. cylindrical measure in 3 layers. (Follow A. S. T. M. Standard Method of Test for Unit Weight of Aggregate for Concrete.)

Coarse aggregates are subjected to the following tests, so far as the quantity of material permits:

(6) Sieve Analysis—Per cent coarser than Sieves Nos. 8, 4, ⅜ in., ¾ in., and 1½ in. (Follow A. S. T. M. Tentative Standard.)

(7) Abrasion—Use Deval abrasion machine; follow A. S. T. M. Standard or Mattimore's method if aggregate furnishes pieces of proper size; otherwise use test as modified by Rea and Abrams.

(8) Unit Weight—Puddle with 1/5 to 1 cu. ft. cylindrical measure in 3 layers. (Follow A. S. T. M. Method of Test for Unit Weight of Aggregate for Concrete.)

(9) Concrete Strength—Compression tests of 6 in. by 12 in. concrete cylinders at ages of 7 and 28 days, using 1:4 mix with local concrete sand, graded up to No. 4 sieve. Make 5 cylinders on different days from separate batches, mixed by hand. (Follow A. S. T. M. Tentative Methods of Making Compression Tests of Concrete, 1921.)

(10) Wear of Concrete—Use 8 in. by 8 in. by 5 in. blocks; 1:4 mix; relative consistency 1:10; test at 28 days. Mold specimens in metal forms and finish by hand. Make 5 specimens. Test in Talbot-Jones rattler; 1,800 revolutions at 30 r. p. m.

Sieve Analysis of Aggregates (1 and 6)

The sieve analysis of aggregates is important, but it must be properly interpreted. The sieve analysis reveals the quality of the aggregate so far as size and grading of the particles are concerned, and these are important factors in producing good concrete for both strength and wearing resistance, as has been shown by many tests. All scientific methods of proportioning aggregate for concrete are based on the sieve analysis. The practice of mixing fine and coarse aggregates in fixed proportions without regard to size and grading should be discouraged. A number of researches have been published during the past two or three years which indicate methods of dealing with this problem by use of the sieve analysis of the aggregate. Elaboration of these methods is not within the scope of this paper.[4]

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[1] Paper before American Road Builders' Association, Jan. 19, 1922; Revised and corrected Jan. 30, 1922.

[2] Progress Report of Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. Proceedings Am. Soc. Testing Mat., 1921. Proceedings Am. Soc. Civil Eng., August, 1921.

[3] See Wear Tests of Concrete, by Duff A. Abrams; Proceedings Am. Soc. Testing Mat., 1921.

Good concrete can be made from aggregate of almost any size and grading (if of good structural quality), providing these characteristics are properly taken into account in designing the mix.

The following from the tentative specifications of the Joint Committee on Concrete and Reinforced Concrete, places the grading of fine aggregates on the proper basis:

> Fine aggregates shall range in size from fine to coarse, preferably within the following limits:
> Passing through No. 4 sieve—Not less than 95%.
> Passing through No. 50 sieve—Not more than 30%.

It will be noted that the grading is not mandatory; if fine aggregate of other grading is used, the proportions of cement, coarse aggregate and water must be such as to give concrete of the desired quality.

There is a marked tendency now to go to larger sizes of coarse aggregate in concrete roads; a number of specifications now admit aggregate up to 3 in. or coarser; this tendency should be encouraged. The use of the coarsest pieces which are practicable improves the quality of the concrete and reduces crushing and screening costs.

In this connection it may be well to say a few words on the relation between laboratory sieves and the sizes of material produced by commercial plants, which use circular screens made of perforated steel plates. A little consideration will show, and the investigations of the Bureau of Public Roads[5] have proven that the size of aggregate produced by a commercial screen is determined by one or more of the following factors, which have no relation to the size of the opening:

(1) Thickness of plate.
(2) Wear on plate.
(3) Diameter of screen.
(4) Length of screen.
(5) Inclination of screen.
(6) Rate of rotation.
(7) Rate of feed.
(8) Wet or dry screening.

In other words, a sieve analysis under standardized conditions is necessary in any case to give the *actual sizes* of material produced.

The writer wishes to emphasize the advantages which would follow from the general adoption of the sieves recommended by the American Society for Testing Materials, for Sieve Analysis of Aggregate for Concrete (that is, Nos. 100, 50, 30, 16, 8, 4, 3/8 in., 3/4 in., 1 1/2 in., and 3 in. square openings) in all specifications for concrete roads and for laboratory use. They now have the backing of the Bureau of Standards, the Joint Committee on Concrete and Reinforced Concrete, as well as other influential organizations. These sieves are on a scientifically sound basis, in that the width of the clear openings of each sieve is exactly double that of the next smaller one, and the ratio of wire diameter to clear opening follows a definite law.

ORGANIC IMPURITIES IN SANDS (2)

Organic impurities in sand is objectionable, due to the fact that it either greatly retards or entirely prevents the setting and hardening of the cement. Such impurities generally result from carelessness in stripping the overburden from sand and gravel pits. The colorimetric test made by digesting a sample of the sand in a 3% solution of hydroxide,[6] which originated in this laboratory, is becoming generally accepted as a satisfactory criterion for this purpose.

SILT IN THE SAND (3)

In usual concrete work a small percentage of silt in sand is not objectionable, so long as it does not contain organic impurities and providing an excess of mixing water is not used. In the wearing surface of concrete roads, however, silt is especially objectionable, since it is likely to be drawn to the surface in finishing, thus producing a weak and friable concrete, where concrete of the highest quality is needed. The quantity of silt should not be greater than 3% by weight. The use of sands of higher silt content should be permitted only when there is good reason to believe the following precautions will be taken:

(1) Reduction of the quantity of sand to a minimum.
(2) Reduction of the quantity of mixing water to a minimum.
(3) Surface worked as little as possible in finishing.

The quality of concrete will in any case be improved by following precautions (1) and (2).

MORTAR STRENGTH OF FINE AGGREGATE (4)

Most specifications require tensile strength of 1:3 mortar briquets; however, the compression test is much to be preferred. The comparison with 1:3 standard sand mortar at 7 and 28 days gives valuable information, providing the test is properly interpreted. If three sands give mortar strengths of 70%, 100%, and 130% of standard Ottawa sand, it does not follow that *concrete* made from these sands will show the same strength-ratios. In fact, they will show about 90%, 100%, and 110%. The reason for this lies in the fact that in concrete the sand is only, say, one-third the total aggregate, hence differences in strength of concrete due to variations in sands may be expected to be only about one-third those found in sand mortars. Sands which fall below standard in mortar tests can be used with good results, providing the mixtures are modified accordingly.

In many instances confusion arises as to whether mixtures for mortar tests should be made by weight or by volume. It is the writer's belief that the *volume* method is more nearly correct, since batches are most frequently proportioned by volume. Sands of a calcareous nature or which are unusually fine are unduly penalized when proportioned by weight.

UNIT WEIGHT OF AGGREGATE (5 AND 8)

The unit weight of an aggregate is of value in arriving at the quantities of materials necessary for concrete of a given mixture, as in A. S. T. M. method of proportioning concrete for laboratory tests. The A. S. T. M. method of determining unit weight of aggregates gives a quantity of material closely equivalent to that required for a batch of concrete of ordinary mixtures.

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[4] For details consult:

(1) "Effect of Grading of Sand and Consistency of Mix upon the Strength of Plain and Reinforced Concrete," by L. N. Edwards, Proceedings A. S. T. M., 1917 Part II., p. 302.

(2) "Proportioning the Materials of Mortars and Concrete by Surface Areas of Aggregate," by L. N. Edwards, Proceedings A. S. T. M., 1918, Part II., p. 235.

(3) "Design of Concrete Mixtures," by Duff A. Abrams, Bulletin 1, Struct. Mat. Research Lab., Lewis Institute, Chicago.

(4) "Proposed Method of Estimating the Density and Strength of Concrete and of Proportioning the Materials by the Experimental and Analytical Consideration of Voids in Mortar and Concrete," by A. N. Talbot, Proceedings A. S. T. M., 1921, p. 940. See also Proceedings A. S. T. M., 1919, Part I., p. 321.

[5] Commercial Sizes of Crushed Stone Aggregate by Jackson and Mitman, *Public Roads*, June, 1918, and June, 1919.

[6] See Abrams-Harder Field Tests for Organic Impurities in Sands, Report of Committee on Concrete and Concrete Aggregates, Proceedings Am. Soc. Testing Mat. Part I., 1919, p. 321. Also Tentative Methods of Test for Organic Impurities in Sands for Concrete, Proceedings Am. Soc. Testing Mat., 1921.

In the case of blast furnace slags and aggregates of unusual types, the unit weight may furnish some indication of the nature of the material.

The old theory that heavy aggregates are better than light ones has little basis in fact.

ABRASION TESTS OF COARSE AGGREGATES (7)

The per cent of wear (or the French Coefficient, which is 40 divided by the per cent of wear) is generally specified for coarse aggregates for concrete roads. The test is made in accordance with the "Standard Method of Test for Abrasion of Road Material" of the American Society for Testing Materials, adopted in 1908. This test was originally used in France about 1878 by M. Deval[7], as a test for crushed rock for macadam roads; it was introduced in this country about 1893 by L. W. Page[8] for the same purpose. Upon the advent of the concrete road the test came to be used as a criterion of the quality of coarse aggregates, for lack of any other method of measuring the abrasive resistance of the material. The test requires 50 pieces weighing 5,000 gm. (about 2½ in. to 3 in. in size), hence, in general, it cannot be made on the aggregate as used in concrete roads, due to the absence of large pieces. The test is meaningless when applied to rounded pebbles. These conditions have led to a number of modifications of the A. S. T. M. test.

In a recent series of investigations of the abrasive resistance and concrete-making properties of about 150 different samples of coarse aggregate, the writer used the four methods of making the abrasive test described in Table 1.

The results of these tests are given in Table 2. Only samples were included for which tests were made by *all* methods. The A. S. T. M. method gives the lowest per cent of wear in each instance; the Mattimore method gave about double the A. S. T. M.; the Rea method about double the Mattimore; the Abrams method gave values which average about the same as the Mattimore method. The different methods do not give the same rating to the different types of coarse aggregate. The values for gravel by the A. S. T. M. method are absurdly low. It is difficult to draw any conclusions from these tests, except to suggest a grave doubt as to whether any of these tests has any significance when applied to aggregates for concrete roads.

The values in Tables 2 and 3 (which do not entirely parallel), show that the type and per cent *of wear of the aggregate* has little influence on the compressive strength or *wear of the concrete*.

The gradual lowering of the requirements in specifications (that is, permitting aggregate of higher and higher per cent of wear) during the past few years, is evidence that practical road builders have reached the same conclusions from experience that has been brought out by laboratory research.

CONCRETE STRENGTH (9)

Testing coarse aggregates by means of compression tests of concrete is not necessary as a routine method of inspection, unless the aggregates present some unusual characteristics. Such tests furnish the best information for research purposes and should be encouraged. Concrete cylinders 6 in. by 12 in. in size should be used if aggregates do not exceed 2 in.; for larger aggregate, 8 in. by 16 in. (or larger) cylinders should be used. The methods recently published in tentative form by the A. S. T. M.[9] should be followed in making such tests.

TABLE 1—METHODS OF MAKING ABRASION TESTS OF COARSE AGGREGATES

All Tests were made in the Deval Abrasion Machine

Method	Weight and Grading of Sample (square - mesh sieves)	Abrasive Charge 1⅞ in. Cast-Iron Balls	Total Revolutions	Remarks
A. S. T. M.*	5000 gm. 2½ to 3 in.	..	10,000	50 pieces.
Mattimore†	5000 gm. 2½ to 3 in.	..	10,000	Same as A.S.T.M. except cylinders provided with 1/16-in. slots which allow fine material to escape as produced.
Rea‡	2500 gm. ⅜ to ¾ in. 2500 gm. ¾ to 1½ in.	6	10,000	Use volume of 0.11 cu. ft. in case of materials of unusual weight.
Abrams	2000 gm. ⅜ to ¾ in. 2000 gm. ¾ to 1½ in.	10	2,000	Use volume of 0.09 cu. ft. in case of materials of unusual weight.

*Standard Method of Test for Abrasion of Road Materials, A.S.T.M. Standards, 1921, p. 710.

†Use of Slotted Cylinder for Abrasion Tests of Rocks, Report New York Commissioner of Highways, 1917, p. 52. Also Proceedings A. S. T. M., Part II., 1918, p. 426. See results of tests made by this method by F. H. Jackson, Proceedings A. S. T. M., Part II., 1920, p. 278.

‡Abrasion Test for Gravel Aggregate, General Specifications for Materials, Ohio State Highway Department, Columbus. Also *Concrete Highway Magazine*, June, 1918. Mr. Rea used screens with circular openings ½, 1, and 2 in. The wire cloth sieves, with square openings, used in our tests give approximately the same separation sizes as the circular screens.

The data in Table 3[10] are a portion of the results obtained in the series of tests mentioned above, in which comparisons were made between the results of tests on agregates and wear and compression tests of concrete. The principal details of the tests are given in the notes which accompany the table. Only aggregates which could be screened and recombined to conform to the grading shown are included. These tests were made in the same investigation as the abrasion tests, in Table 2. It will be noted that Table 2 contains a much smaller number of aggregates than Table 3, due to inability to secure pieces of the sizes necessary for abrasion tests, according to the A. S. T. M. and Mattimore methods. The compression and wear tests were made at the age of 3 months, after curing for 14 days in a damp room and the remainder in air.

These tests show a surprisingly uniform compressive

TABLE 2—ABRASION TESTS OF COARSE AGGREGATES
(See Table 1 for Details of Methods of Making Tests)

Machine operated at 30 to 33 r. p. m.

The per cent of wear was based on the weight of material finer than a No. 16 sieve, or which escaped through the 1/16-in. slots in Mattimore's method.

Method	Per Cent. of Wear Limestone (17)*	Trap (4)*	Granite (3)*	Sandstone (5)*	Slag (3)*	Pebbles (18)*	Grand Av.†
A. S. T. M.	4.8	2.2	1.9	5.0	8.7	0.9	3.9
Mattimore	12.6	4.7	3.8	6.9	17.8	2.6	8.1
Rea	21.0	7.4	18.3	29.5	13.7	10.0	16.6
Abrams	10.5	3.8	8.0	17.1	5.7	4.9	8.3
Ave.	12.2	4.5	8.0	14.6	11.5	4.6	9.2

*Number of different samples.

†Averages not weighted.

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[7] Annales des Ponts et Cahussees, by Deval, 1879. Also Bulletin du Ministere des Travaus Publics, by Deval, 1881.

[8] U. S. Road Materials Laboratory, by Page and Cushman, Proceedings Am. Soc. Testing Mat., 1903. Also Bulletin 79, Bureau of Chemistry, U. S. Department of Agriculture, 1903.

[9] Tentative Methods of Making Compression Tests of Concrete, Proceedings Am. Soc. Testing Mat., 1921.

[10] Reproduced from the author's paper on Wear Tests of Concrete, Proceedings Am. Soc. Testing Mat., 1921.

strength for concrete made of pebbles, crushed limestone, granite, trap, sandstone and slag. It should be noted that all coarse aggregates were of same grading, and that different batches were mixed as nearly as practicable to a uniform consistency. Failure to take into account the effect of differences in grading of aggregate and consistency of concrete in comparing the concrete-making properties of different types of aggregate have led earlier investigators to the erroneous conclusion that there was a wider variety in strength of concrete from aggregates of the same type than for aggregate of different types.

Compression tests made at 28 days after damp-room curing with specimens still damp, will give values about 70% of those in Table 3; 14 days in damp room and 14 days in air, about 75% of values in Table 3.

WEAR TESTS OF CONCRETE (10)

The wear test of concrete by means of the Talbot-Jones[11] rattler furnish an excellent method for research purposes, but is not practical as a routine method of inspection. A ring of 10 separately molded block 8 in. square and 5 in. thick is placed in the rotating head of the machine, where the finished surfaces are subjected to the tumbling action of a 200-lb. charge of cast-iron balls for 1,800 revolutions, requiring about one hour.

TABLE 3—WEAR AND COMPRESSION TESTS OF CONCRETE MADE FROM MISCELLANEOUS COARSE AGGREGATES

Wear tests of 8 by 8 by 5 in. concrete blocks made in Talbot-Jones rattler.

Compression tests of 6 in. by 12 in. cylinders.

Mix 1:4 by volume of mixed aggregate; approximately same as 1:2:3 mix.

Relative consistency, 1.10; about the same as should be used in the construction of concrete roads to be finished by hand.

Hand-mixed concrete: One specimen to a batch.

Cement: A mixture of five brands of portland cement purchased in Chicago.

Sand from Elgin, Ill., graded 0 to No. 4, used as fine aggregate in all tests.

Each coarse aggregate was screened and recombined to the following grading: No. 4 to ⅜ in., 25%; ⅜ to ¾ in., 50%; ¾ to 1½ in., 25% by volume.

For each aggregate sample, the value for wear was the average of 10 tests, and for strength, 5 tests, made on five different days.

Specimens stored in damp condition 14 days then in air until tested at age of 3 months.

Kind	Coarse Aggregate				Concrete Tests* (3 months)	
	Number of Samples Tested	Unit Weight—lb. per cu. ft.	Apparent Specific Gravity	Absorption at 3 hrs.; per cent by weight	Comp. Strength—lb. per sq. in.	Depth of Wear—inches
Pebbles	24	102	2.56	1.17	4330	0.51
Crushed limestone	26	91	2.59	1.14	4560	0.44
Crushed Granite	12	92	2.59	0.32	4350	0.84
Crushed Trap	6	95	2.85	0.12	4210	0.40
Crushed Sandstone	7	86	2.34	3.94	4470	0.45
Crushed Slag	13	88	2.34	2.20	4240	0.48
Crushed Flint	2	88	2.43	....	4850	0.46
Crushed Marble	1	96	2.69	0.39	4620	0.42
Crushed Lava Rock	1	90	2.62	2.50	5350	0.40
Crushed Tufa	1	47	1.27	27.50	1960	0.66
Crushed Fire Brick	1	70	1.92	4.55	5390	0.43
Cement Clinker	2	88	2.22	8.20	5160	0.37
Boiler Cinders	1	40	1.51	8.70	3000	0.85

*Strength tests were also made at ages of 7 and 28 days, and 1 year on many of the aggregates.

The wear tests reported in Table 3 were made by this method and show what may be expected of various types of aggregate when subjected to exceedingly heavy wear. It should be pointed out, however, that concrete pavements rarely exhibit such a degree of wear that the quality of the aggregate becomes an important factor, so long as it conforms to the primary requirements of a good material. The requirements of modern traffic emphasize the necessity for *good concrete,* rather than a straining after highest types of aggregate. Good concrete can be produced from inferior aggregates by proper methods of proportioning, control of mixing water, and curing concrete under favorable conditions. The wearing resistance of a concrete road is much more dependent on the *quality of the concrete* than on the quality of the aggregate.

It should be stated that there is a well-defined relation between strength and wear of concrete; the factors which produce concrete of high strength produce low wear.

SAMPLING OF AGGREGATES

Tests of aggregates are worthless and are likely to be entirely misleading unless the sampling is properly done. Particular care must be used in sampling under the following conditions:

(1) Sand, gravel, or slag in undeveloped pit.
(2) Coarse aggregate in cars or stock pile.
(3) Rock in native ledge.

The Tentative Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Material of the A. S. T. M., published in 1921, should be followed wherever applicable.

In selecting samples for tests in the laboratory the method of quartering may be used, or, better yet, some form of sample splitter.

A very common mistake is to furnish samples to the laboratory which are too small for proper tests. Complete tests require about 50 lbs. of fine aggregate and 100 lbs. of coarse aggregate.

FIELD TESTS OF AGGREGATES

In prospecting for aggregate supplies, or in making preliminary examinations of aggregates at their source, or after delivery, valuable information can be obtained from tests made in the field with portable apparatus. Tests which are the most significant and which lend themselves readily to field use are *sieve analysis* and the test for *organic impurities.*

Certain of the state highway departments furnish their inspectors with a set of sieves, made up in semi-cylindrical form and nested in a metal can. An approximate sieve analysis of almost any aggregate which is likely to be encountered can be made by use of the No. 50, 16, 4, and ¾ in. sieves. The first three sieves will give an analysis of fine aggregate which is sufficiently accurate for all purposes and probably far more accurate than the sampling. The last two sieves will give sufficient data on size and grading of coarse aggregate; the maximum size can always be determined by visual inspection. A large number of trials made by the writer in the laboratory show that by making sieve analysis of a wide variety of aggregates with the four sieves and interpolating the values for intermediate sieves, curves could be platted which compared quite favorably with those secured from the sieve analyses of the same aggregates, using the complete set of sieves.

The colorimetric test for organic impurities can readily be made in the field by using a graduated prescription bottle, with a supply of sodium hydroxide in stick form, the pieces being made up in advance of such size as will give approximately a 3% solution.

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[11] See the author's paper on Wear Tests of Concrete, Proceedings Am. Soc. Testing Mat., 1921.

An excellent idea of the quality of native rock can be obtained by examining outcroppings and exposed ledges and noting the effect of weathering.

The importance of care in sampling must not be overlooked even in field tests.

NEED FOR FURTHER RESEARCH AND STANDARDIZATION

The foregoing remarks make apparent the need for further research and standardization of methods of dealing with concrete aggregates.

Field tests now under way by the Bureau of Public Roads and by the State Highway Departments of Illinois and Pennsylvania may be expected to give important results on the relative merits of different aggregates. The Bureau of Public Roads, a number of state highway departments, and other laboratories now have under way investigations of aggregates which have thrown light on the properties which must be met for good results.

CONCLUDING REMARKS

No attempt has been made in this brief review to suggest a complete specification for aggregates for concrete roads; however, certain principles which should govern the selection and the use of aggregates are given.

There is a marked tendency to disregard minor features in specifying concrete materials and to base final conclusions on the *quality of concrete* produced.

The characteristics of the aggregates are only one of the many factors which enter into the making of good concrete. The best aggregates do not insure superior concrete, if the methods of proportioning, mixing, placing and curing are faulty. Good concrete roads can be built of inferior aggregates, if the other elements are handled in such a way as to get the best out of the concrete.

Preliminary Estimate Figures

BY CHARLES F. DINGMAN
PALMER, MASS.

The figures presented here are intended to serve as a means for rapid preparation of a preliminary estimate of the cost of a factory building, following either the standard mill construction type or the usual type of reinforced concrete construction.

It is not intended that this method shall be used as a substitute for the detailed quantity survey method of estimating, though it may be used as a check on the results obtained in that way, but this method is much more accurate than the usual method of using the unit cost per square foot of one building to estimate the cost of a building of similar construction, but of different dimensions.

When it is remembered that the relative amounts of floor and wall costs change with every change in the shape of the building, it will be appreciated that a square foot price which might apply for a small square building might not apply at all for a larger oblong building.

This method of preliminary estimating was not originated by me; all I claim for the present figures is that they have been computed on the basis of current prices and verified by comparison with prices for buildings actually placed under contract. I usually find that a preliminary figure made this way will come between the high and low figures submitted as final bids. It is, therefore, safe for use for the purpose for which it was intended.

PRELIMINARY ESTIMATE FIGURES
(Revised to November 22, 1921)

Computed by Chas. F. Dingman, M. Am. Soc. C. E., and verified by comparison with costs of buildings actually placed under contract.

Mill Construction—Walls and Foundations—Per Linear Feet

	Outside	Inside
One-story	18.30	18.10
Two-story	32.10	28.60
Three-story	51.70	38.40
Four-story	75.10	62.75
Five-story	98.46	83.50
Six-story	123.10	106.00
Tar-rok, hm. and mpl. floor	.55 per sq. ft.	
Floor construction	.58 per sq. ft.	
Lining floor, extra	.06 per sq. ft.	
Roof construction	.54 per sq. ft.	
Saw tooth roofs, wood sash	.69 per sq. ft. Additional	
Saw tooth roofs, G. I. sash	.90 per sq. ft. Additional	
Stairs	$25.00 per ft. rise	
Plumbing	$200.00 for 1st 2,500 sq. ft. $100.00 for each added 2,500 sq. ft.	

Reinforced Concrete Buildings
Outside Walls, including Foundations, Columns, etc.

One story high	16.40 per lin. ft.
Two stories high	33.40 per lin. ft.
Three stories high	53.20 per lin. ft.
Four stories high	74.25 per lin. ft.
Five stories high	98.50 per lin. ft.
Six stories high	126.00 per lin. ft.

Interior Columns

One story high	80.00 each
Two stories high	141.00 each
Three stories high	190.00 each
Four stories high	274.00 each
Five stories high	355.00 each
Six stories high	450.00 each
Stairs	35.00 per ft. of rise

Floor and Roof Construction

First floor, cement on earth	.23 per sq. ft.
Reinforced floors inc. topping, 150 lbs. L. L.	.97 per. sq. ft.
Reinforced floors, inc. topping, 200 lbs. L. L.	1.09 per sq. ft.
Reinforced floors, inc. topping, 250 lbs. L. L.	1.25 per sq. ft.
Reinforced floors, inc. topping, 300 lbs. L. L.	1.37 per sq. ft.
Reinforced floors, inc. topping, 350 lbs. L. L.	1.46 per sq. ft.
R. C. roof const., inc. covering	.73 per sq. ft.
Single wood floor, add	.22 per sq. ft.
Double wood floor, add	.29 per sq. ft.
Hardener, add	.06 per sq. ft.

Interior Partitions

	Per Linear Foot 1 sty. high
4-in. gypsum	3.24
6-in. gypsum	4.32
4-in. hollow tile	2.52
6-in. hollow tile	3.00
8-in. hollow tile	3.60
10-in. hollow tile	4.68
12-in. hollow tile	6.36
8-in. brick	5.40
12-in. brick	8.10

The figures given in this article are based upon the following unit prices:

Bricklayers' time	$1.00 per hour
Carpenters' time	.85 per hour
Laborers' time	.45 per hour
Portland cement	$3.00 per bbl. delivered
Brick	21.00 per M. delivered
Sand	1.50 per yd. delivered
Gravel or stone	2.50 per yd. delivered
Timber	60.00 per M. fbm deliv.
Plank	45.00 per M. fbm deliv.
Flooring	60.00 per M. fbm deliv.

Variations of these costs will affect the figures in the tables as follows:

Mill Construction Floors

Each change of 5 cents per hour in carpenters' rate	0.91%
Each change of $1 per M. on timber	0.31
Each change of $1 per M. on plank	0.78
Each change of $1 per M. on flooring	0.21

Mill Construction Walls

Each change of 5 cents per hour in bricklayers' time	0.46%
Each change of 5 cents per hour in laborers' time	0.65
Each change of 10 cents per bbl. on cement	0.20
Each change of $1 per M. on brick	1.14

Reinforced Concrete Construction

Each change of 5 cents per hour in carpenters' rate	0.43%
Each change of 5 cents per hour in laborers' rate	1.25
Each change of 10 cents per bbl. on cement	0.46
Each change of 10 cents per yd. on sand	0.13
Each change of 10 cents per yd. on gravel	0.22

How to Make Forms for Concrete Buildings —*Columns*

The Third Article of an Important Series Written for the Builder Who Wants to Know the Subject From the Beginning

By William F. Lockhardt
Lockhardt-Byrne Co., New York City

> The literature of form work is scanty. It especially fails to meet the needs of builders who are obliged to begin at the beginning to study the subject. Contractors and superintendents have repeatedly asked Concrete to publish articles whose authors would not take it for granted that their readers already knew most of the subject. The editors cast about for the right man to prepare such articles, and were fortunate in getting the promise of William F. Lockhardt to do the job. The first article of the series, on "Footings," the second, presented last month on walls; this month "Columns." The series will be continued. Mr. Lockhardt's descriptions of form work are based on the actual practice of some of the most successful concrete building contractors in the United States. Various methods have been tried, and these methods have survived. If any reader is in doubt about some step in form building, when he has read Mr. Lockhardt's article on any one of the special subjects in the series, he will be conferring a favor on the editors and on many readers if he will ask to have the point more fully explained. A reader who has used form building methods different from the methods here described, and which he believes better for any reason whatever, will be adding something to the consideration of a very important subject if he will describe those methods for this magazine.—The Editor.

Forms for interior and exterior columns are usually of different construction. The forms for exterior columns are usually rectangular in plan, while those for interior columns may be square, octagonal, or round, and if the latter, are frequently of sheet metal instead of wood. For any of these, the construction of the column head or capital will vary according to the type of floor construction, the requirements for beam and girder construction being quite different from those for flat slab.

Sheet metal column forms are usually confined to round columns. As the light metal that is used in these forms is lacking in strength to uphold the floor form system, it is necessary where these forms are used that special provision be made at the column for supporting the floor forms. This will be discussed later.

Wood forms for circular columns are not frequently met with, as to be used with any degree of success certain conditions must be fulfilled. Under favorable conditions, however, they may be entirely satisfactory.

Rectangular and octagonal column forms are usually of wood. Differences in length of sides, size of yokes, etc., have to be taken into account on rectangular or square forms, according to whether they are for interior or exterior columns.

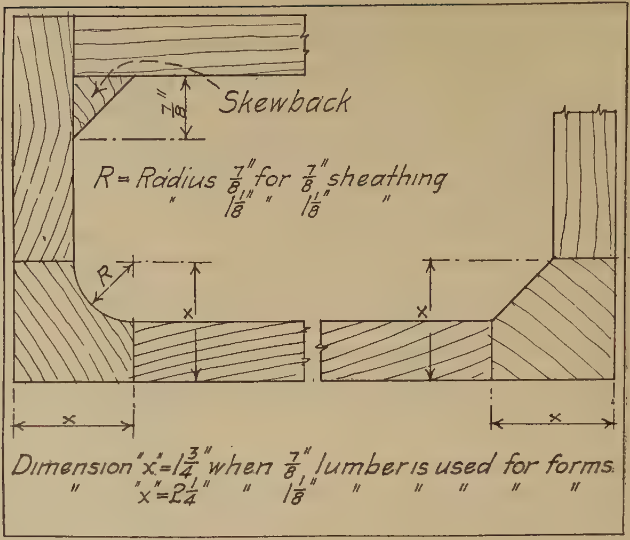
Skewback
7/8"
R = Radius 7/8" for 7/8" sheathing
" 1 1/8" " 1 1/8" "
R
x
x
x
x
Dimension "x" = 1 3/4" when 7/8" lumber is used for forms
" "x" = 2 1/4" " 1 1/8" " " " " "

Fig. 1—Methods Used to Get Beveled or Bullnose Corners on Columns

It has been found that the construction is simplest and the board marks least conspicuous when the boards run vertically. For small columns, 7/8-in. roofers may be used, but the common practice is to use 1¼-in. lumber, dressed four sides, tongued and grooved (D 4 S, T & G).

The necessity for avoiding sharp edges is well known. The green concrete will get nicked and chipped in the operation of removing the forms, and some method should be used to avoid a sharp arris. The simplest method is by beveling the corners, accomplished by inserting in the corners of the form a triangular wood strip called a "skewback." Sometimes a better appearance is desired, which may be obtained by the use of a rounded corner, or "bullnose," in which case a cove molding must be built into the forms. Fig. 1 shows plans of the corner of a column for each of these arrangements, with the usual dimensions. These may of course be varied if it is so desired.

The column sides are stiffened and braced by yokes or battens, according to the system of clamping pre-

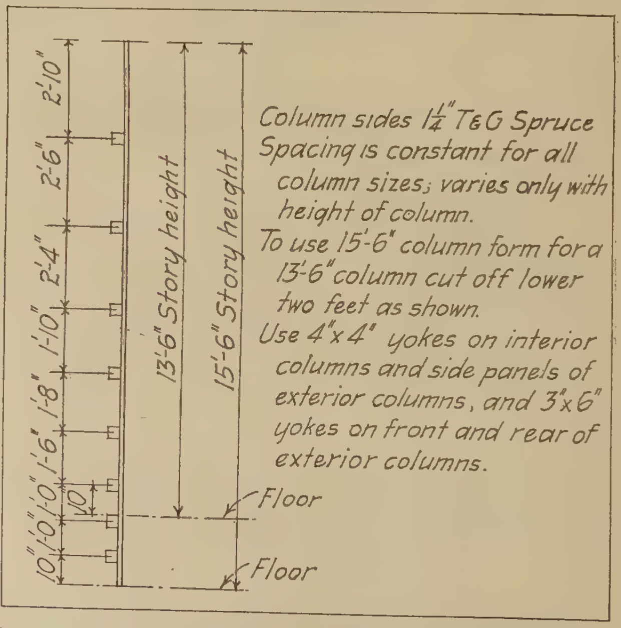
2'-10"
2'-6"
2'-4"
1'-10"
1'-8"
1'-6"
1'-0"
1'-0"
10"
10"
13'-6" Story height
15'-6" Story height
Column sides 1¼" T&G Spruce
Spacing is constant for all column sizes; varies only with height of column.
To use 15'-6" column form for a 13'-6" column cut off lower two feet as shown.
Use 4"x4" yokes on interior columns and side panels of exterior columns, and 3"x6" yokes on front and rear of exterior columns.
Floor
Floor

Fig. 2—Schedule for Vertical Spacing of Column Yokes or Clamps

ferred by the contractor. With yokes, bolts or rods, malleable iron clamps are most frequently used. With battens the different types of patented form clamps are adopted. Concrete exerts a pressure on the forms equal to that of a liquid weighing approximately 125 lbs. per cu. ft., according to experiments conducted by the Bureau of Standards. As this is twice the weight of water, the necessity for ample strength in yokes and bracing will be seen readily. The pressure varies with the depth, not with the thickness of the concrete in the column. The yokes are spaced more closely toward the bottom of the column, as this is where the pressure is greatest.

A schedule of yoke spacing used by one concrete contractor is given in Fig. 2, for 13 ft. 6 in. and 15 ft. 6 in. story heights. For intermediate story heights follow the same spacing of yokes, starting with one yoke 10 in. from the floor, and making the variation come in the top space. The 3 in. by 6 in. face yokes may usually be used for columns up to about 3 ft. or 3 ft. 4 in. face, but for columns having a face width greater than 3 ft. it is generally better policy to use 4 in. by 6 in. yokes. For columns having a face width close to 5 ft. it is best to through bolt the lower half of the column in the center, to relieve the strain on the yokes for the long span.

As it is not desirable in an article of this sort to go into a comparison of different patented systems of column yokes and ties, descriptions will be given only of the different types of bolted or wedged constructions, as used by most of the large contractors. From these the contractor or carpenter foreman may make comparison with the different clamps offered him. There are a number of these devices on the market, which appear to have considerable merit for certain purposes, but as a rule they lack the adaptability of bolts, which can be used anywhere and everywhere. There are usually no more loose parts to handle with bolts than with many of the patented clamps, and the parts, if lost, cost less. Numerous loose parts in a clamp are a disadvantage. There are more parts to be picked out for assembling, which means time and money, and experience shows that as a rule the men will drop and lose a 35c special casting just as cheerfully as they will a 2c washer. In figuring comparative costs, this possible high replacement charge must be taken into account. Some clamps are dependent upon the lumber running true to size. It won't. A 4 in. by 4 in. yoke piece may be anywhere from 3¾ in, to 4⅜ in.; the writer has found both dimensions at opposite ends of the same 16 ft. 4 by 4. This may require sizing, or packing out, which always costs money. These points are mentioned in passing to emphasize that the adoption of a new clamp ought to be preceded by a careful, thoughtful investigation to find if there are any "kinks" in it that will give trouble when the device is put to practical use.

Bolts for column forms are usually ⅝ in. Half-inch bolts have been used by a good many contractors with satisfaction, but for some types of form construction are found to be too light to withstand the strain of wedging against them as will be described under square and rectangular columns. As it is usual to stock only one diameter of bolt on the job, these bolts would also be used for wall construction, and half-inch bolts bend quite readily in pulling; ¾-in. bolts are heavier than necessary in building construction, and have generally been abandoned except for special heavy work.

Cast iron washers may be used, or wrought iron "plate" washers may be bought. These latter are usually 3 in. by 3 in. and cut from ⅛-in. iron. For heavy construction these will not be heavy enough, so to avoid confusion some contractors have standardized on ¼-in. plate washers. For ⅝-in. bolts or rods the hole is generally ¾ in. Square-head bolts and square nuts are used.

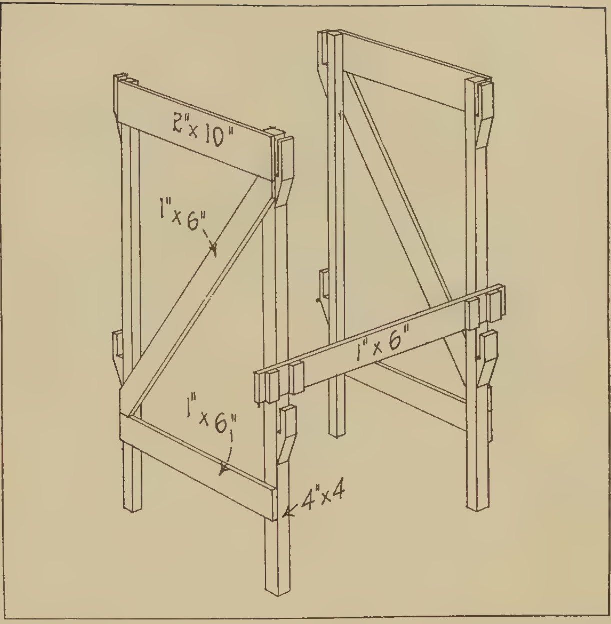

Fig. 3—Bent for Supporting Floor Forms at Columns When Sheet Metal Column Forms Are Used

Now as to form details. We will first take:

Circular Columns

Sheet metal forms for circular columns are ordinarily rented from an agent of the manufacturer, who erects and strips them at a fixed price per column. As these forms are not designed to carry the weight of the floor form construction, provision must be made to support either the drop panel, in flat slab construction, or the beams and girders framing into the column in beam and girder forms. Such a support has been detailed in Fig. 3. This form of bent can be used equally well for either beam and girder or flat slab construction by varying the height dimension as required. The uprights are 4 by 4's, the top horizontal brace is a 2 by 10, the lower horizontal brace and the diagonal are 1 by 6's. The bent is made up of two sides, each of which is permanently assembled; the two sides are set up in place either side of the column center, and the movable horizontal braces dropped into place in sockets on the sides of the bents. If necessary the completed frame is stiffened with temporary diagonal staylathing of 1 by 6's. In stripping, the horizontal braces are lifted out of the sockets, and after the wedges have been removed from under the posts the two bents may be taken down and hoisted to the next floor complete, ready for re-assembling.

In flat slab construction a flared capital is provided on the column which extends up to the drop panel. The construction of the drop panel and the connection of the capital to it will be described under "Flat Slab Forms."

The method of patching out the column head between beams and girders will be taken up in "Beam and Girder Construction."

Wood forms for circular columns must be made up of staves set in a yoke. The faces of the staves and the yoke must be shaped to circles of the right diameter for the size of the column and the thickness of the staves (see Fig. 4). The radius of the curve on the inner face of the staves will of course be one-half the diameter of the column. The radius of the curves cut in the yoke will be one-half the diameter of the column plus the thickness of the stave.

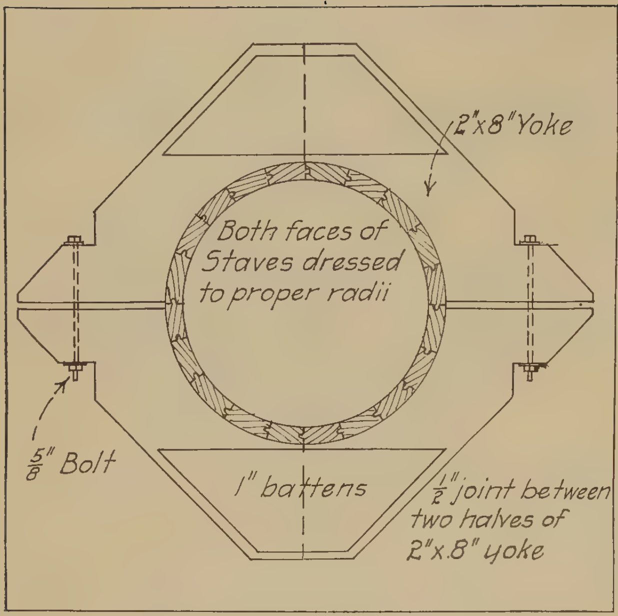
2"x8" Yoke
Both faces of Staves dressed to proper radii
5/8" Bolt
1" battens
1/2" joint between two halves of 2"x8" yoke

Fig. 4—Plan of Wood Stave Form for Circular Column

If the diameter of the column is to be reduced it can only be accomplished by making a new form, as a form made up in this manner cannot be reduced in diameter satisfactorily and economically. Wood forms for circular columns are therefore practical only where a building is one story high and quite long, so that the forms may be used over again a number of times. If the building is two stories high, the upper story columns will have to be of the same diameter as those in the first story. Briefly, the governing condition is that there must be opportunity to use the forms over again often enough to bring down the cost of the form per column, and the columns must be all of the same diameter.

The form is bolted together through the yokes, which are notched out as shown in the drawing to provide a square seat for the washers on the bolts.

Rectangular Columns

Rectangular and octagonal column forms are usually of wood. The exterior columns of a building usually keep the face that is parallel to the building line unchanged, the reduction being made in the "thickness" (dimension at right angles to the building line). Interior columns are often square, and in this case all four faces will have to be reduced in width. The necessity for being able to reduce the size of a column economically must not be overlooked in planning the forms.

The arrangement of sides shown in Fig. 5 is very largely used and has been found simple to build and reduce and quite generally satisfactory. The drawing shows a rectangular form for convenience in referring to the different panels. The face panels (as marked on the drawing) are usually called the "sides" and the narrower panels, which fix the thickness of the column, are called the "ends."

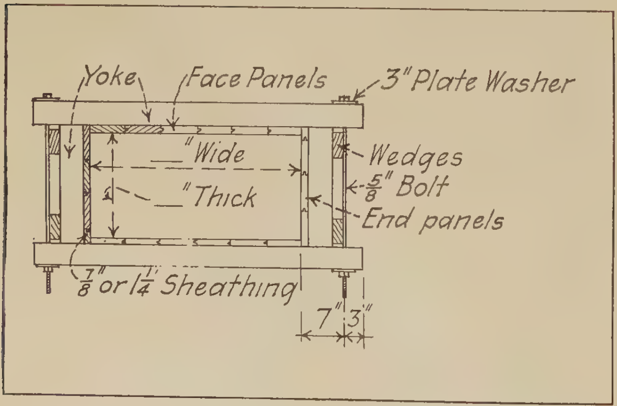

Fig. 5—Plan of Form for Typical Square or Rectangular Column

A square column would be built just the same as the drawing shows, the dimensions of the different panels alone being changed.

The width of the sides is just the same as the concrete dimension. This panel is made up on long yokes, which also serve as battens, which project about 10 in. beyond the panel at each side, to allow space for bolting and wedging. The end panels are wider than the concrete dimensions for the thickness of the column by twice the thickness of the lumber used in the panels. A glance at the drawing will show why. Necessarily, the yokes on the end panels are cut off flush with the sides of the panels.

For exterior columns, as the upper stories are added to the building it will be found that with each succeeding floor or two the thickness of the column will be reduced, as the load on the column reduces, and a smaller column area is required. Architectural appearance demands that the face of the column that shows on the street be the same width from street to cornice, so the smaller area is obtained by reducing the thickness.

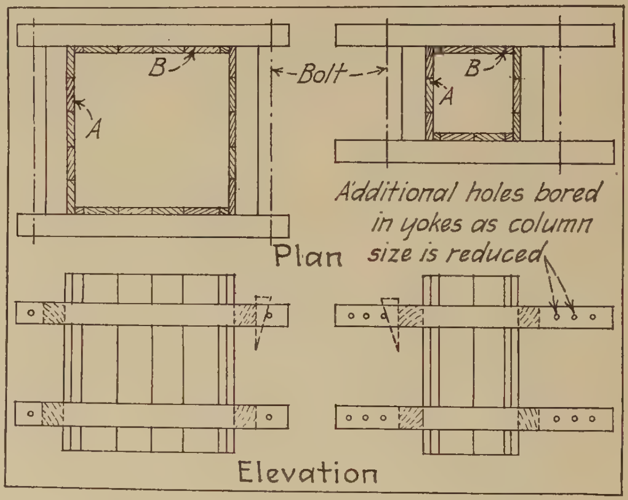

Fig. 6—Method of Reducing Form for Square Column

This merely means that to reduce the column form a strip the same width as the required reduction in the thickness of the column is ripped off one side of the end panels, cutting through panel and yokes alike.

After the panels are assembled the bolts are placed and tightened up, and then the wedges shown in the drawings driven down between the bolts and the 4 in. by 4 in. cleat or yoke piece on the ends, to hold the end panels tightly in place against the sides. It is here that a ½-in. bolt frequently proves too light, as it will bend under the wedging or later under the pressure of the concrete.

The change in panels necessary to reduce a square column to a smaller size is shown in Fig. 6. The end panels marked "A" on the drawing are reduced in a slightly different manner from the end panels on an exterior column. It is necessary to cut one-half the desired reduction off each side, cutting through panel and yokes together. The panels that carry the long yokes—marked "B" in the drawing—are treated in another way. The outside board at each side of the panel is removed and replaced by a narrower board, so that one-half the

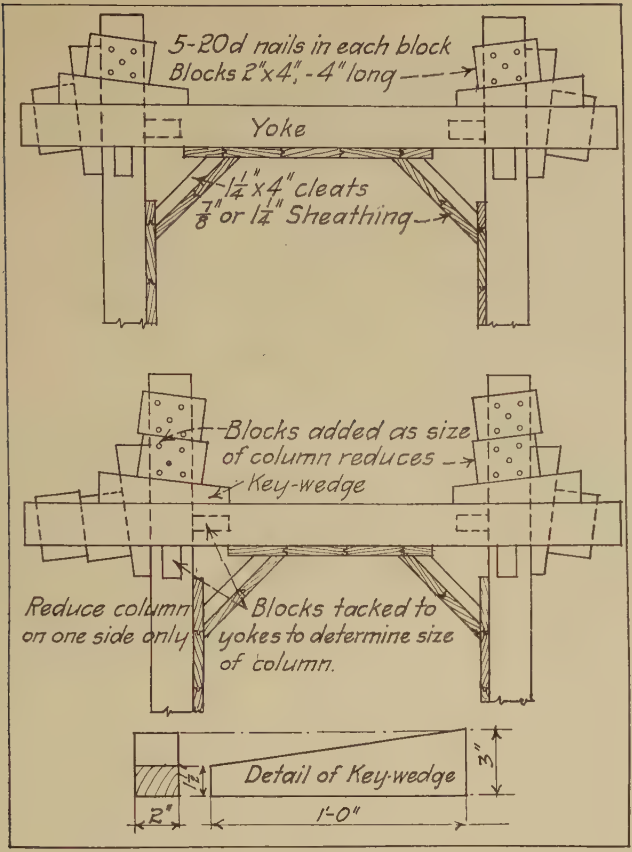
5-20d nails in each block
Blocks 2"x4", -4" long
Yoke
1¼"x4" cleats
⅞" or 1¼" Sheathing
Blocks added as size of column reduces
Key-wedge
Reduce column on one side only
Blocks tacked to yokes to determine size of column.
Detail of Key-wedge
3"
2"
1'-0"

Fig. 7—Method of Yoking or Clamping a Column Without Bolts by the Use of Keys

required reduction is taken off each side. The reason for this is easily understood. As the column head is usually an integral part of the column form, and the column head in a beam and girder job has openings on all four sides in the center for the beams, the reduction must be made equally on each side of the center to keep the beam where it belongs. If the job is flat slab, with a separate column head, then the reduction may be made on one side of each of the panels; the method of clamping a column as shown in Fig. 7 is better adapted for this reason to flat slab construction.

When the column is reassembled it will be found that the bolt holes in the long yokes are now so far away from the end panels that it will either be necessary to use blocking behind the wedges or to bore new holes. When a power boring attachment to the sawmill is set up at the beginning of the job it will be found a money-saver to bore as many holes as may be necessary in the yokes before they are sent to the bench where the column sides are made up. The holes may be spaced about 3 in. apart.

Skewbacks are usually nailed to the side panels, so that the end panels will bear tightly against them.

A method of yoking up a column to avoid the use of bolts is shown in Fig. 7, referred to above. The method is shown applied to an octagonal column, but of course can be applied as readily to a square column. As it is more convenient with this method to make the reduction on one side only of the column, the column head will have to be altered if the job is beam and girder, or the beams and girders will be off center. This method is quite old, but is occasionally used. The wedges can be driven out and the form taken down very quickly.

All the panels for an interior column are of the same length. This length will be equal to the story height, less the thickness of the floor slab, and the thickness of the floor panels, which rest on the top of the column. Thus for a 12 ft. story height, with a 4-in. slab, the column sides would be 12 ft. less 4⅞ in., or 11 ft. 7⅛ in. long. In figuring the depth of the beam opening in the column head, the thickness of the slab and the thickness of the floor panel must be taken into account. For exterior columns the column panels will be of different lengths. The exterior face of the column is longest, as it extends from the top of the floor slab above to the supporting brackets on the column of the story below, these brackets being usually 6 in. or more below the floor level of the next lower floor. The two end panels sometimes extend from floor to floor level, but are not as long as the panel for the exterior face of the column. The panel for the interior face of the column is the shortest of all, being no longer than one of the panels for an interior column.

Fig. 8 shows an exterior column completely assembled and set in place. After the form is assembled complete it is of course supported by the floor, but provision must be made to support the outside face of the column temporarily, as this is always the first piece to be hoisted and set in place. Reference to the drawing will show how this is done. Near the top of the column form two bolts will be seen on the interior face. In a corresponding position in the story below will be seen two 4 in. by 4 in. brackets. Before the column is concreted 9 in. studs with nuts on the inside end are placed in the two bolt holes and allowed to project about 4 in. outside the form. When the column is stripped these bolts remain in place in the concrete, and the 4 by 4 blocks are slipped over them and tightened up. Before being placed these blocks have had a notch cut in one end, as shown, so that when the form is hoisted it is stepped into these two notches, and held upright by 2 in. by 4 in.

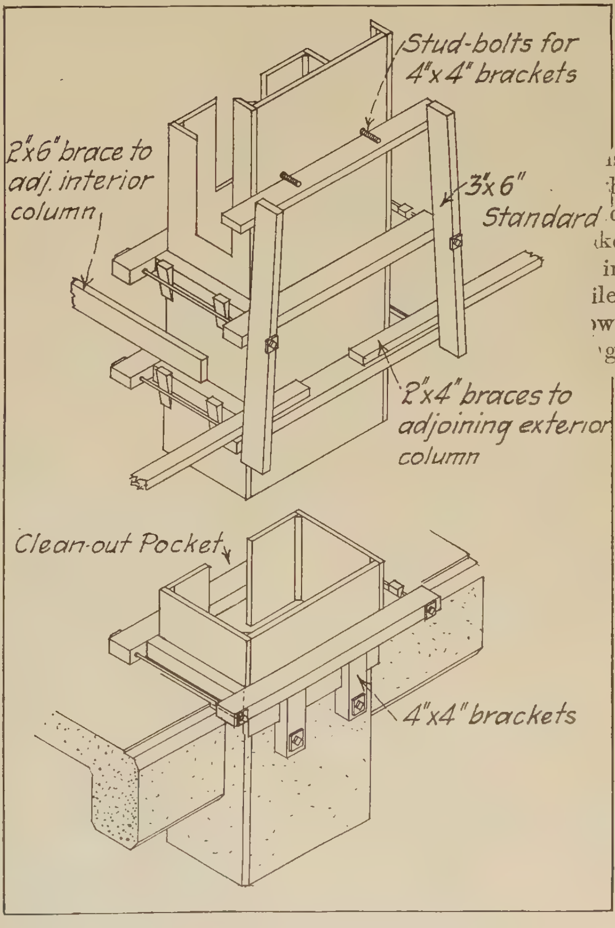
Stud-bolts for 4"x4" brackets
2"x6" brace to adj. interior column
3"x6" Standard
2"x4" braces to adjoining exterior column
Clean-out Pocket
4"x4" brackets

Fig. 8—Exterior Column Form Set in Place

braces run back to blocking on the floor. The remaining panels are set up in position when convenient.

Because of the interference of the beams on the building line, the top yoke on the column is not continuous around it, and special provision has to be made to keep the upper part of the column form from bulging out. This is done by means of a pair of 3 in. by 6 in. vertical cantilever stiffeners, or standards, bolted to the highest continuous yoke, and long enough to bear against the next yoke below and the top yoke above. By using this arrangement it is not necessary to bolt through the exterior girders, or beams. It is usual to tie the columns together as shown in Fig. 8 by means of 2 by 4's run parallel to the building line to the adjacent exterior columns, and by 2 by 6's run to the opposite interior column.

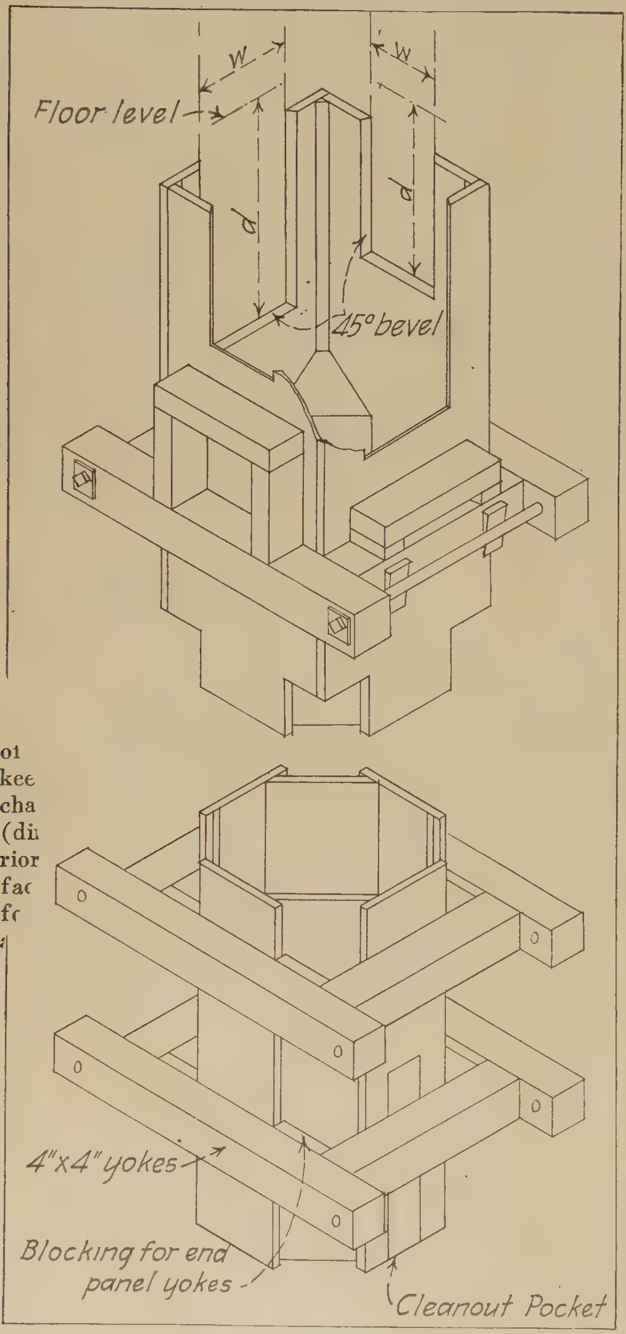

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Fig. 9—Typical Octagonal Column Form

Notation—W = Beam or girder width plus 1 in. for margin around opening.

d = Beam or girder depth, plus thickness of slab, plus ⅞ in. for thickness of floor panel, plus ½ in. margin at bottom of opening.

Octagonal Columns

The octagonal column form used to be used very extensively for interior columns, but it has of late been superseded by the circular sheet metal form. There are still a number of places, however, where it can be used to good advantage, so the details are given in Fig. 9. The general method of construction is similar to that followed for square columns, except the panels on the yokes are no wider than may be necessary to engage the bevel pieces in the corners. This makes it necessary to put a small bearing block on the long yokes for the "end" panel to bear against.

Column Heads and Capitals

Both square and octagonal columns have square heads; the four corner pieces of the octagonal column are capped with a three-cornered piece to give the effect in the finished column of a chamfer stop. This piece shows in Fig. 9. Openings for beams and girders are cut with a 45° bevel as shown. The beams and girders do not actually frame up tight against the column form, but are separated from it by removable keys which provide the necessary clearances and make stripping easy.

With flat slab construction a flared capital is necessary on top of the shaft of the column. With circular metal column forms the capital is also of sheet metal, furnished and erected the same as the shaft, and need not be dealt with here. Where wood forms are used for interior columns a square of octagonal capital will be required according to the shape of the column.

The square capital is a little simpler than the octagonal. It is generally built up of two long sides and two short sides, that fit in between them, as shown in Fig. 10. All the panels are made up for the largest column, and as the size of the column reduces the panels are pieced out as indicated in the section in broken lines. The octagonal form is somewhat similar, but beveled corner pieces are inserted in the corner of the square capital form, as indicated in broken lines at "A" in the plan. These heads are sometimes supported temporarily by making the top yoke of the column long enough to carry

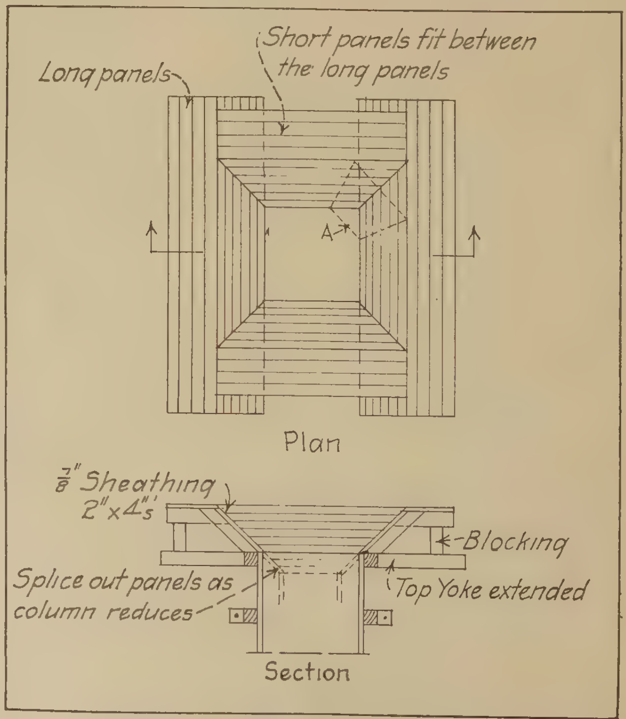

Short panels fit between the long panels
Long panels
A
Plan
⅞" Sheathing
2"x4"s
Blocking
Splice out panels as column reduces
Top Yoke extended
Section

Fig. 10—Flared Head for Square or Octagonal Column

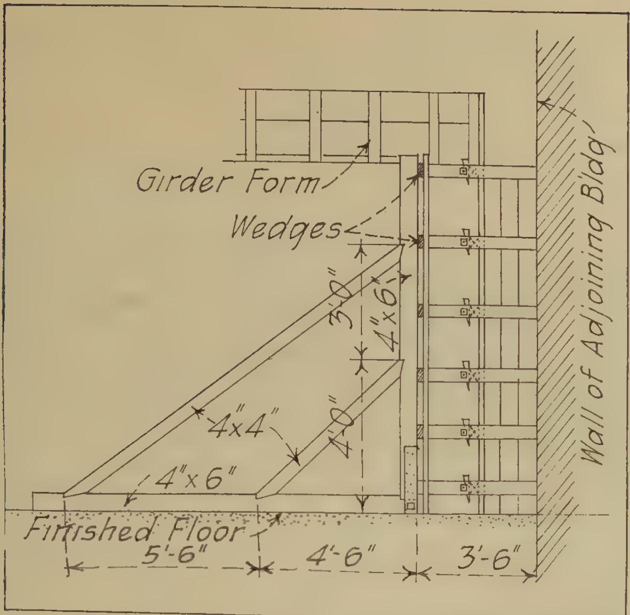


FIG. 11—METHOD OF BRACING COLUMN FORMS AGAINST AN EXISTING WALL

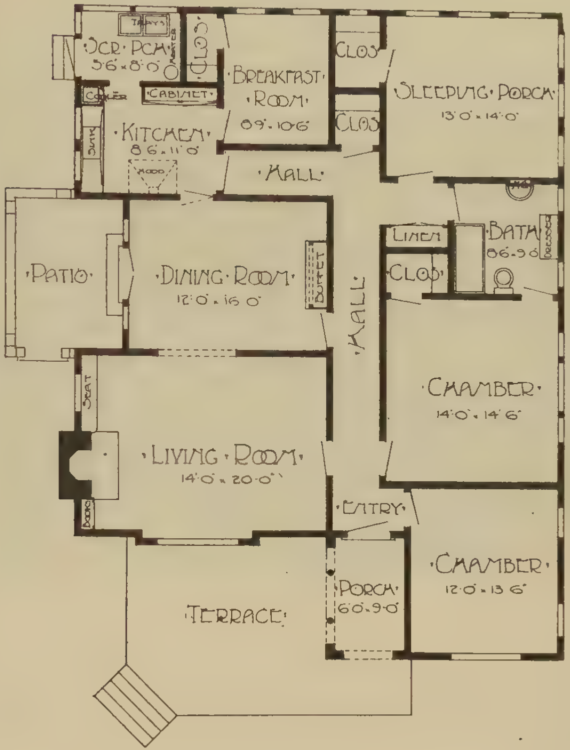
them, as shown in the section in Fig. 10, but before any concrete is poured they should be posted up.

MISCELLANEOUS

A minor problem occasionally encountered is that of holding in place a column which adjoins an existing building. An arrangement similar to that shown in Fig. 11 may be easily made up, and in actual service this has proved very satisfactory. The frame of 4 by 4's and 4 by 6's is made up separately and put into place as a unit and the wedges between the column yokes and the vertical 4 by 6 are driven afterward to make the whole frame tight.

It is generally considered good practice to put a grade mark on one bar in each column on every floor with an engineer's level, so that any irregularities in the first floor level will not be carried all the way up through the building. This mark is generally a file cut at some predetermined elevation, such as 10 ft. or 12 ft. 6 in. below the next finished floor level (or rough floor level, as the case may be). The carpenter foreman can thus tell his men to make all the column forms say 9 ft. 7 in. long above the grade mark, and they can cut off or splice out the lower end of the column according to the condition at each individual column.

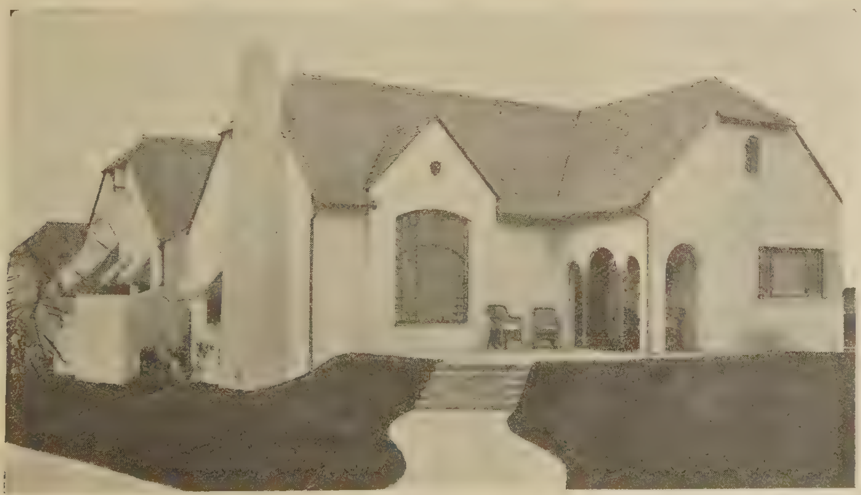
A Bungalow Plan From California



The plan and picture show a Los Angeles bungalow with light cream cement stucco on frame; trim mahogany; shingle roof red.

The woodwork finish in the living room and dining room consists of old ivory with mahogany trim; of old ivory alone in the hall, breakfast room and sleeping rooms, and of white enamel in the kitchen and bath room. The walls of the living room and dining room are painted in a light buff tint; in the sleeping rooms and breakfast room they are papered; and in the bath room and kitchen they are finished with a smooth, hard plaster coat to a height of 4 ft. 6 in. and enameled like woodwork. Oak flooring is used throughout, except in the bathroom and kitchen. The bathroom floor is of tile.

The house has neither basement nor cellar. It, however, is equipped with built-in gas radiators for heating, and all other modern conveniences.



BUILT IN LOS ANGELES FROM PLANS BY THE DE LUX BUILDING CO.

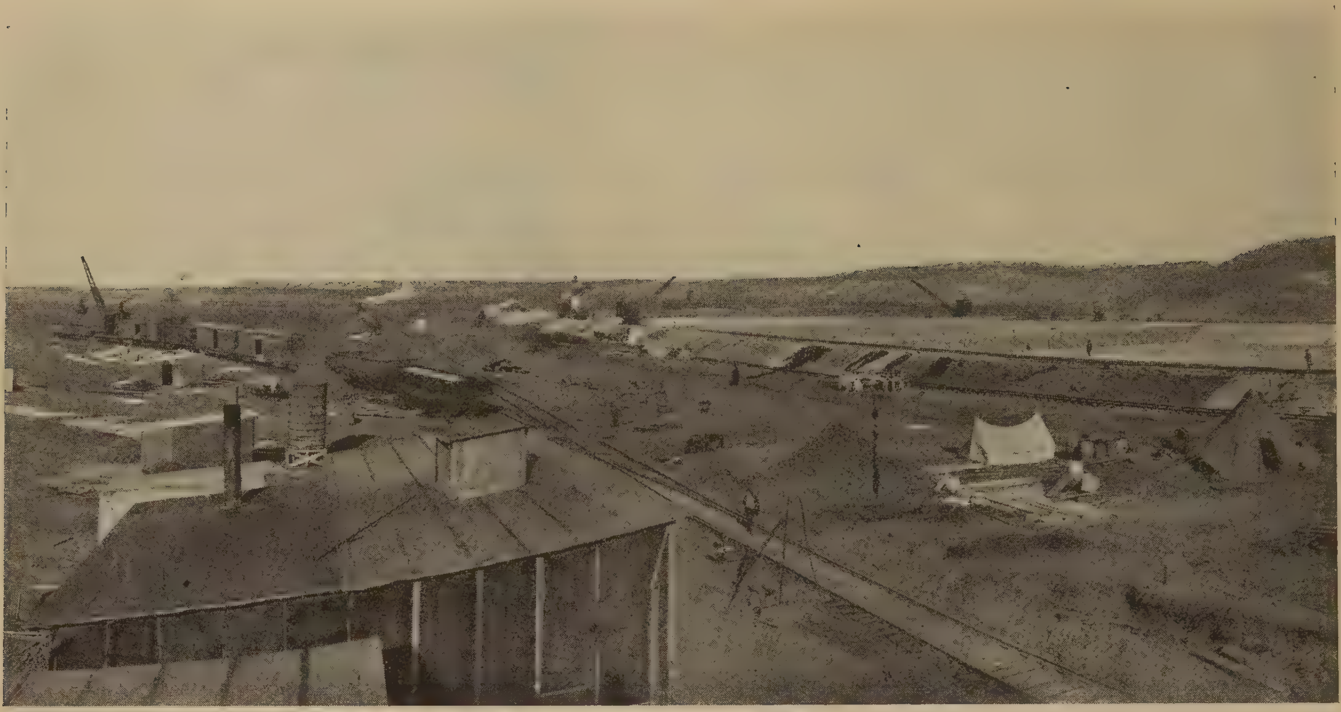


FIG. 1—PANORAMA OF NITRATE STORAGE RESERVOIR

Nitrate Storage Pit of Reinforced Concrete Constructed in Record Time

A reinforced concrete pit, 1,634 ft. long, 234 ft. wide, and 10 ft. deep, was constructed in less than four months at Savannah Proving Ground, Illinois, for the storage of sodium nitrate which is held in reserve at different points throughout the country under the supervision of the Ordnance Department of the United States Army.

The pit was constructed on a tract of land known as "Sand Prairie," the soil being composed of fine sand, which affords the best possible sub-soil drainage. The bottom of the pit is placed entirely in excavation, and the slope walls at the sides and ends of the pit partially in excavation and partially on embankment. The grading for the pit amounted to 50,000 cu. yds. of earth excavation. The walls are sloped, the plan dimensions given above being at the top. The length and width in the bottom of the pit are 1,600 ft. and 200 ft., respectively. The pit is divided into eight pockets, 200 ft. by 200 ft. along the bottom, by means of seven cross walls. The entire structure is reinforced concrete, the bottom and slope walls being 5 in. thick, reinforced with ½-in. bars, 12 in. on centers in both directions. The cross walls are 8 in. thick on top and 12 in. on the bottom, and are reinforced with a layer of steel near each face, consisting of ½-in. bars on 12 in. centers, both horizontally and vertically. A total of 7,000 cu. yds. of concrete of 1:2:4 mix was poured in the pit and given a troweled finish. The bottom of the pit is divided by means of ½-in. expansion joints 50 ft. apart in both directions, and the slope walls are provided with ½-in. expansion joints every 50 ft. Beneath all of the expansion joints a 6 in. by 18 in. reinforced concrete footing was placed, which was covered with tar paper before pouring the top course. All expansion joints were filled with coal-tar pitch.

It is proposed to fill the pit with sodium nitrate to a depth of several feet above the top of the pit at the center, sloping the top of the stored nitrate down to the ends and sides of the pit, and to cover the stored nitrate with a Barrett specification roof. Roof drainage is to be taken care of by means of a reinforced concrete gutter, 30 in. wide, varying in depth from 6 in. to 24 in., along each side of the pit. In order to handle any excess water which might result from rainfall during the filling process, a sump was constructed on each side of each of the eight pockets, making a total of 16 sumps. The sumps are constructed from 36 in. terra cotta pipe placed vertically, with a concrete coping around the top and cast iron manhole cover. The bottom of the sumps are connected with the bottom of the pits by a 12 in. terra cotta pipe about 25 ft. long.

Three small mixing plants were kept busy pouring

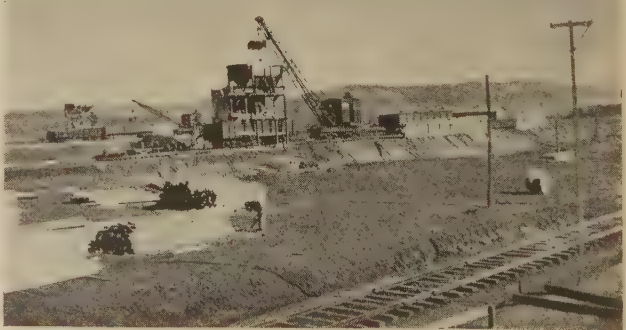
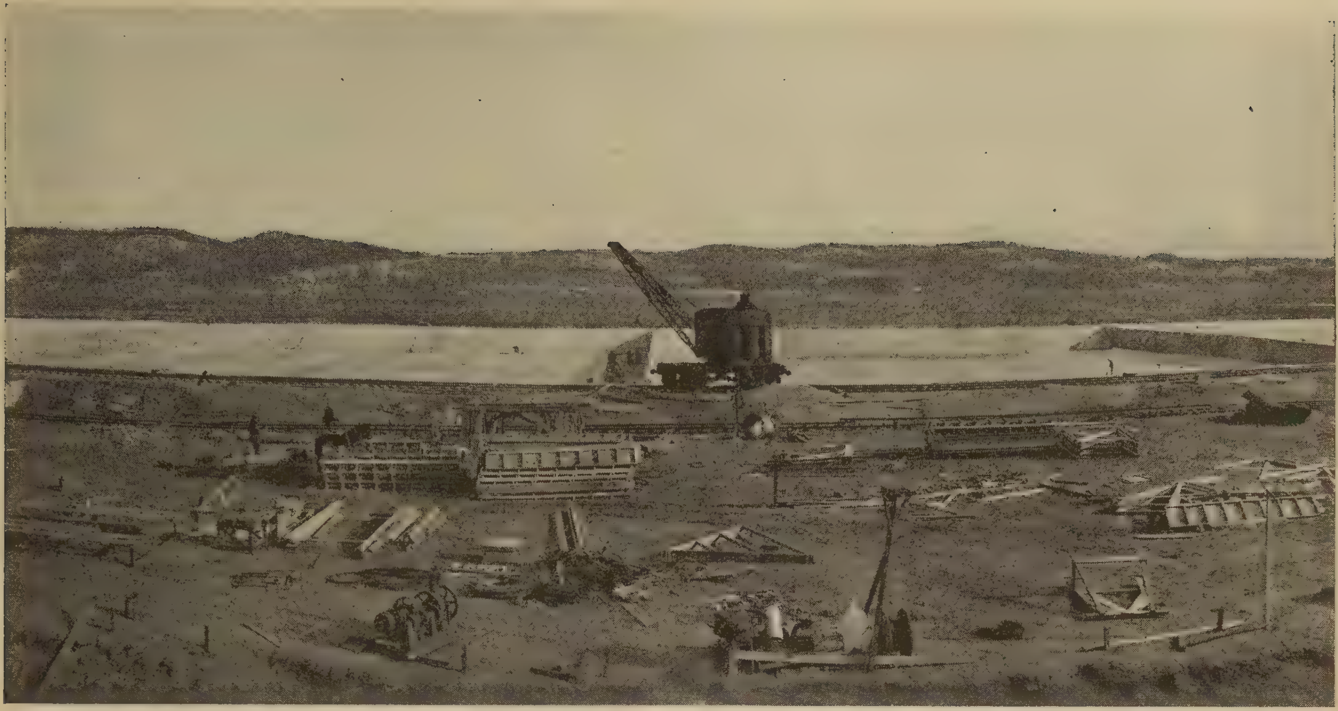


FIG. 2—VIEW OF CONSTRUCTION PLANTS MOUNTED ON FREIGHT CARS FOR CONVENIENT TRANSPORTATION, WITH LOCOMOTIVE CRANES TO SUPPLY MATERIAL TO HOPPERS



at U. S. Army Proving Grounds, Savanna, Ill.

side slope walls, two large mixing plants mounted on gondola cars moved slowly but surely down either side of pit, pouring concrete for the floors and cross sections. Buckets carried concrete to the center sections, which were too far for spouting. A fine spirit of rivalry was kept up between forces on opposite sides, and companies of men worked night and day under thousands of yards of canvas, pouring concrete which was protected from freezing by the burning of the salamanders.

The difficulties of construction were added to by the location of the enterprise, in the heart of a sand desert, about nine miles from the nearest railroad. Wells had to be dug, living quarters and commissary established, and sixteen miles of railroad built before actual construction work was started.

The pit was designed by the Ordnance Department of the Army and constructed under the supervision of the Construction Service of the Quartermaster Corps of the Army. The general contractor was the Henry W. Horst Co., Rock Island, Ill., which sublet the grading to

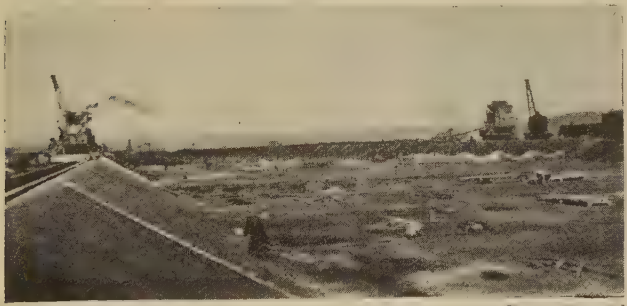


Fig. 5—Side Slopes Ready for Placing Reinforcing; Some Cross Wall Reinforcing in Place; Two Complete Plants on Opposite Sides of Pit

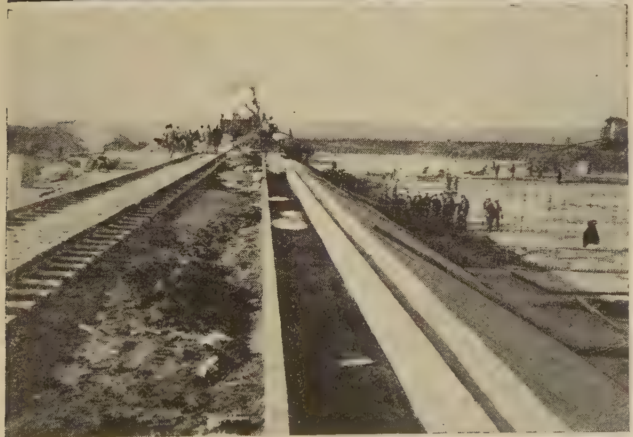


Fig. 6—Portion of Completed Gutter and Side Slope—Cross Wall Reinforceing Steel Being Placed for Seven Cross Walls

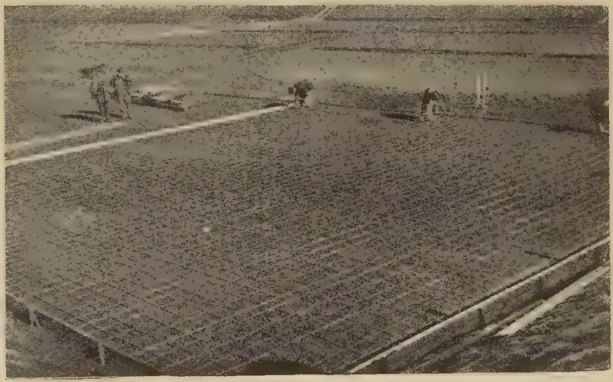


Fig. 7—Floor Slab Reinforcing in Place

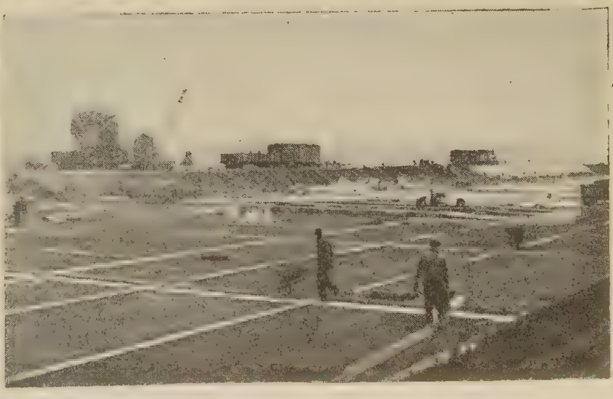


Fig. 8—Placing Concrete in Floor Slab

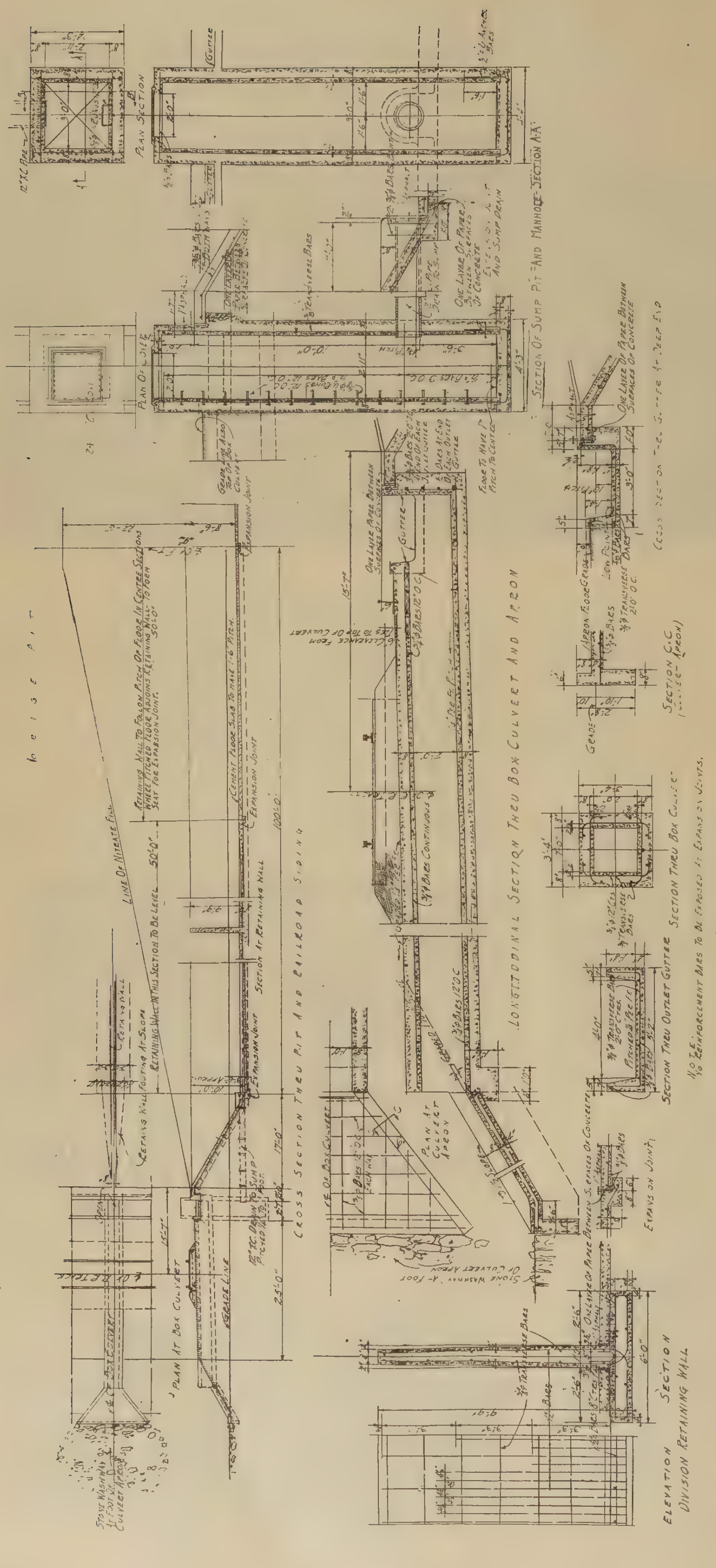

Plan Section
Section Of Sump Pit "And Manhole" Section A-A
Plan Of Culvert
One Layer Of Paper Between Surfaces Of Concrete
Cross Section Thru Pit And Railroad Siding
Line Of Nitrate Fill
Retaining Wall
Section At Retaining Wall
Expansion Joint
Cement Floor Slab To Have 1/6 Pitch
Grade Line
Plan At Box Culvert
Stone Washway At Foot Of Culvert Apron
Longitudinal Section Thru Box Culvert And Apron
Plan At Culvert Apron
Section C-C (Culvert Apron)
Section Thru Box Culvert
Section Thru Outlet Gutter
Note: No Reinforcement Bars To Be Exposed At Expansion Joints.
Cross Section Thru Gutter At Deep End
Elevation
Section
Division Retaining Wall

Fig. 3—Details of Construction

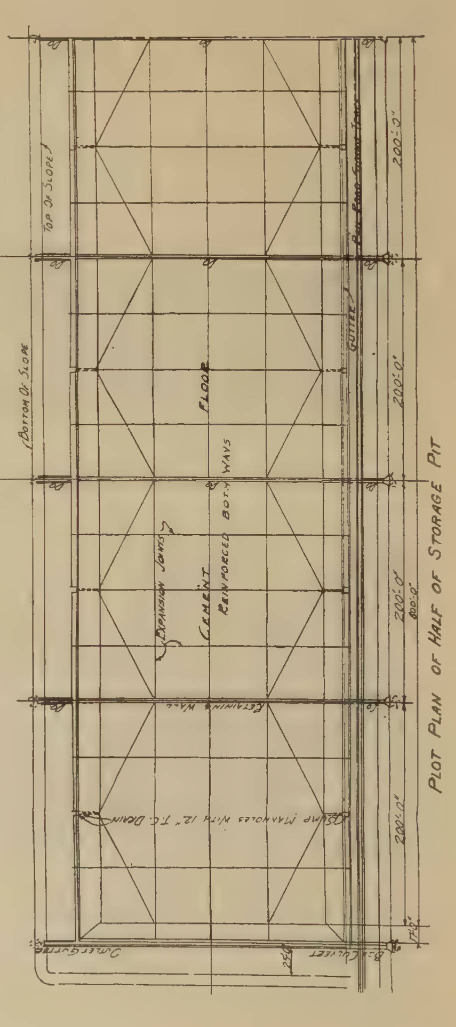


Fig. 4—Plot Plan of One-Half of Nitrate Storage Pit

PLOT PLAN OF HALF OF STORAGE PIT

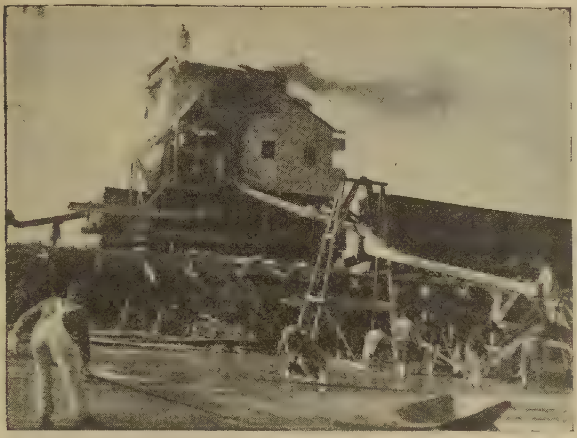


Fig. 9—Pouring and Finishing Floor Slab Near Embankments

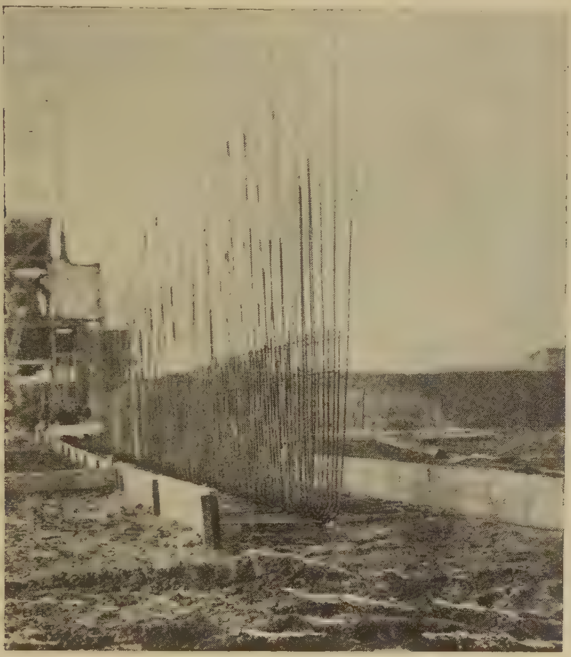


Fig. 10—Cross Wall Reinforcing in Place—One of Seven Cross Walls

William J. Newman, Chicago, Ill. Construction was started in September, 1920, and completed in December, 1920, three days before the specified date. The concrete was placed successfully during freezing weather, by means of heating the aggregate and the water before mixing, and maintaining the temperature by salamanders. A temperature of 60° F. was insisted upon for the concrete when leaving the mixer. The cost of the pit was $307,432.30.

You are invited to take advantage of the Information Service of this magazine. If the Editors can't answer questions, they frequently know who can.

Concrete in Front Line Work, 1914-1917

By Edwin C. Eckel[1]

In preceding articles of this series, attention has been concentrated on the manfacture and distribution of cement and cement products by and to the American Expeditionary Forces. It remains to discuss very briefly the utilization of these materials in purely military work, and for that purpose it will be necessary to consider the employment of concrete by the other armies in front-line works. The A. E. F. entered action at a time when the war of position had ended, and a period of open warfare had commenced. The American forces had therefore practically no experience in heavy front-line construction, and it is necessary to draw upon the very extensive practice and experience of the French, British and German armies in order to get even an outline of the subject.

At the outset it will be well to set limits within which we may find matter of technical interest for future study and operations. There is obviously little to be gained by discussing details of design or particular types of structures. These were matters which were in a continual state of flux, varying with each change in the methods of artillery preparation and of infantry attack; and differing, moreover, according to the sectors in which they were employed. Those who only saw the Lorraine sector in 1918 are apt to underestimate the importance of the subject, and they are also likely to overlook the manifold changes and variations that had been practiced and experienced at different points along the Western Front. Any proper discussion of these phases of the subject would require a broad historical basis, as well as detailed technical knowledge, and for such a complete discussion we will have to look to British, French or German sources.

On the other hand, there are technical features of less variable type that can be discussed with some degree of definiteness. These include such matters as the kinds and qualities of the cement used by the different armies; the kind and quantity of aggregate for the concrete; the methods of mixing; the relative utility of plain and reinforced concrete; the amount and type of reinforcing used; the thickness of concrete required for adequate protection from shell fire; and the use of molded concrete products. On most of these points there are ample data now available, and any engineer who has the available time can treat these subjects in great detail.

In the present article no such detail will be attempted. A few of the more important points developed during the period 1914-1917 will be outlined, so that their bearing on the general problem may be understood, and further studies facilitated. For convenience in following the evolution of concrete structures during that critical period, these scattered notes will be arranged in chronological order, so as to give some idea of the successive phases through which the military applications of concrete passed during the World War.

I. The Border Fortresses, 1914

The German advance through Belgium had been a matter of common discussion in French, Belgian and English military circles for some thirty years, yet when it came to pass in 1914 practically no preparations had been made to meet it. The French armies had mobilized facing northeast, with their extreme left near Maubeuge; the serious German attack struck west of that fortress. The French staff had not risked putting Reserve formations in the line; Von Kluck, as the striking arm of the German forces, was given three Reserve corps and four active corps to form his army. The Allies had the preponderance of total forces on the Western Front; the Germans had superior forces at the points of serious contact.

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[1] Major, Engineers, U. S. R.

The immediate sequel to all this was a somewhat sudden collapse of Allied resistance along the western portion of the line, and the retreat to the Marne. The later events—the resistance at the Marne, the northward advance of the Allies, and the four years of war which followed, came as distinct surprises to the military intelligence of both sides. For both staffs had for many years been conscientiously preaching the doctrine of the short and merry war; of the decisive frontier battle; and of the dissolution of resistance which must necessarily follow the first defeat. Von Schlieffen and Foch had been equally convinced and clear on those points: "The armies which we will place in movement will be made up of civilians torn from their families. The war will bring troubles with it, ordinary life will cease, and consequently the war cannot last very long."[2]

During this first stage of the war the border fortresses of Belgium and France offered the first lessons in the matter in which we are now interested, in that they showed the effect of heavy shell fire on old-line masonry of one sort or another. But the lessons were not entirely clear or connected and the conclusions drawn from them must be carefully limited. It will be well to review the events, and to see what they suggest.

The main French fortress line—Verdun, Toul, Epinal, and Belfort—was not seriously attacked at this stage; and for that matter, only Verdun was ever attempted later in the war. The first blows fell upon the Belgian fortresses and upon Maugeuge. The conditions and the results were widely different.

The Belgian fortresses—Liege, Namur and Antwerp —had all been planned by Brialmont, and were all substantially similar in general plan and in structural detials. In each case a ring of detached concrete-steel forts encircled an old central work. In each case the intervals between the detached forts were long, and were left open in time of peace, with the idea that in war they would be blocked by temporary works, and held by a large garrison, with the support of active field armies The Germans brought against them artillery of greater range and larger calibre than had even been considered sufficiently mobile for siege use—the Austrian 12 and German 16-in. howitzers, for example; and it was proven —if proof had been needed, that heavy guns, allowed to choose position freely, can break down even very heavy masonry. But in each case, long before this condition had been reached, the defended cities had fallen, owing to two very different and unrelated causes. In the first place, the German fire, even from its first positions, had been able to reach the interior of the city. In the second place, German infantry and even cavalry had been able to penetrate between the forts, through the undefended intervals, and enter the towns. It is obvious that under such conditions neither the utility of permanent fortification nor the particular modes of its use received any fair test.

At Maubeuge the defense was far more successful, under far worse original conditions. The works at Maubeuge consisted of an *enceinte* dating from the time of Vauban, surrounded by a ring of detached works some 25 miles in circumference—which gave a radius of only four miles from the center of the town. This ring was made up of six old forts, constructed between 1874 and 1885; and of six more modern works, built in 1894-1895. The six old forts were masonry works, in high relief, and offered excellent targets. Two of them mounted a six-inch gun under a cast-iron turret. Three of them had been recently provided with a three-inch gun in a steel-and-concrete turret. Only one of the old forts had been given a concrete protection after the first experiments with high explosives around 1887.

Of the six newer works all were essentially infantry redoubts, with shallow shelters of non-reinforced concrete for the men, and each had two $3\frac{1}{2}$ inch guns mounted in the open. The intervals between some of the works were large; there was a three-mile gap, for example, between the fort of Boussois and the infantry work La Salmagne.

The weakness of Maubeuge was accepted by the French General Staff because of its location at the extreme west of the intended area of operations. As late as June, 1914, the commandant of Maubeuge had suggested the difficulties of any serious defence, and the head of the General Staff had responded brightly: "Be more optimistic, I will charge myself with the responsibility for Maubeuge; we will send you and your men to take part in the siege of Metz."

Now from this outline it can be seen that Maubeuge was not as strong as the Belgian positions, yet it held out far longer, under far greater difficulties. The garrison was of 32,000 men; the German investing force was about twice as strong. The strength of the Maubeuge defence lay in the fact that it was conducted as an active infantry defence; its weakness arose from the fact that the infantry had no adequate artillery support or cover. There were only sixteen mobile field guns in the entire camp, to serve with the infantry.

The state of the fortress artillery has been noted; the heaviest gun mounted was an old model six-inch; the maximum range of any piece was six miles or so. Under these conditions, the attack took form rapidly. The retreat of the French and British armies had left Maubeuge entirely isolated; after some sharp infantry actions the German guns took position as they chose, and settled down to pound the forts to pieces, one after the other. A brilliant attempt to destroy the main German 16-inch howitzer position having failed, nothing prevented the accomplishment of the program.

One by one the forts and the infantry redoubts were broken into pieces, or ground into powder, according to their type of construction. The accompanying photographs give an idea of the differences in these respects. Of immediate interest in our present connection, aside from the comparison between concrete and cement-laid masonry, was the action of the mass concrete used in the infantry shelters as at La Salmagne (Figure 4). The concrete here was good plain concrete, made from portland cement and gravel. The slabs and masses were broken under shell fire, but they were *broken* cleanly, as by direct shock, and not shaken to pieces or disintegrated, as in the later experiences at Verdun. My idea of the difference in results is that at Maubeuge the damage was done by relatively few direct hits from heavy howitzers, which owing to the weakness of the defense artillery could be brought up close and registered very exactly on their targets. At the Verdun forts the damage was done by a long continued artillery preparation over the whole area, inflicting a maximum of vibration

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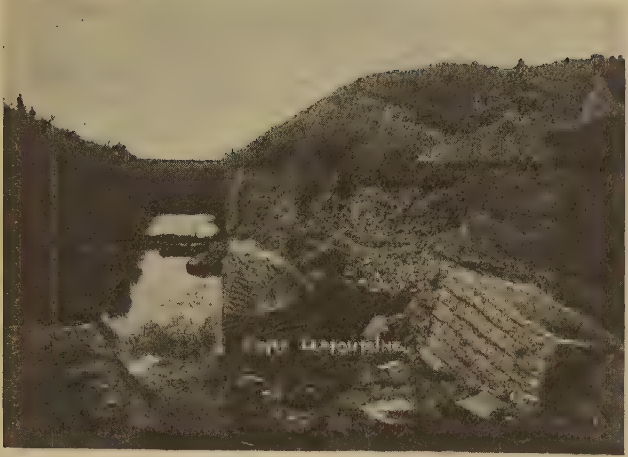
[2] Foch, *Les Principes de la guerre.*



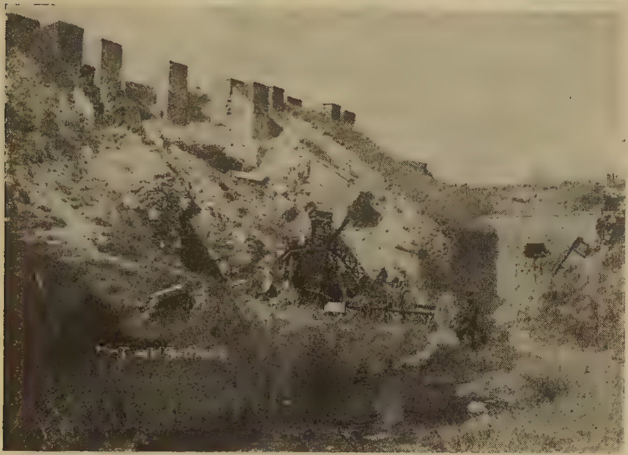
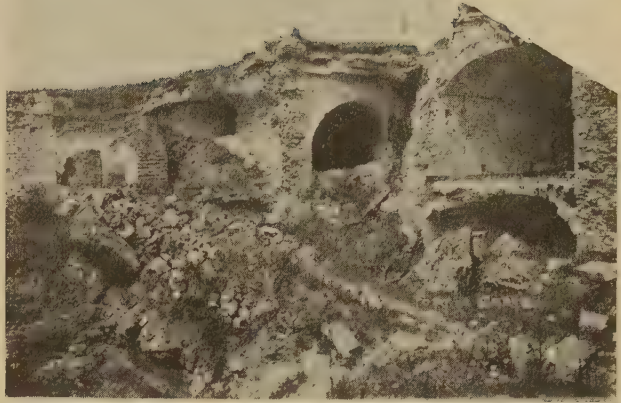


Fig. 1—Ditch and Scarp of Fort Cerfontaine, Maubeuge.
The revetment of the Scarp is cut stone laid in cement backed by rough stone grouted. The only concrete shown is the mass in the foreground which fell owing to slipping of foundations.

Fig. 2—Interior of Fort de Hautmont, Maubeuge, After Surrender.
The masonry shown was brick and stone, laid in cement. No concrete was used here.



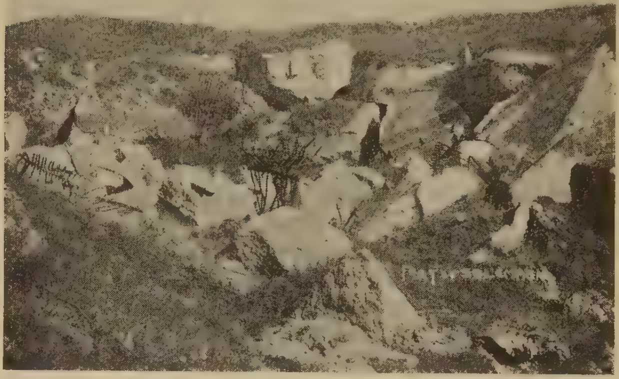


Fig. 3—Interior of Fort de Sarts, Maubeuge.
The masonry is mostly stone laid in portland cement. At base of arches the masonry in all these French forts was stone in hydraulic lime. A few brick-and-cement facings were employed in interiors.

Fig. 4—Infantry Work, La Salmagne, Maubeuge.
The concrete masses shown were parts of the shelters, they were of plain concrete, with a maximum thickness of 3 ft. The concrete here has failed under direct shock, not by being disintegrated by continued shocks as at Verdun. The difference was that at Maubeuge the shelling was done by high-calibre howitzers, which owing to the weakness of defense artillery could be brought up close and registered exactly on targets.

with perhaps far fewer direct single shocks. In any case the difference in the appearance of the concretes at the two points is very noticeable.

The fall of Maubeuge, under the circumstances, was to have been expected; but the final surrender unfortunately covered up the fact that its defence had been surprisingly better than those of the Belgian fortresses, in 1914, or others further east in 1915. For example, Maubeuge had held out for fifteen days; the best of the others, Novo-Georgiewsk, would hold for only twelve, though it had 90,000 men and 1,600 guns, with two lines of modern forts in its defence. The best test of the relative values of the resistance offered by the different fortresses is perhaps the time which elapsed in each case between the installation of the German 12 and 16-inch howitzers and the fall of the first forts. This was in the case of Maubeuge 8 days; Antwerp 4 days; Liege, Namur and Novo-Georgiewsk 3 days; Kovno 2 days and Brest-Litowsk one day. As for its effects upon the campaign in progress, Maubeuge had held a German force of 60,000 men or more in check during the battle of the Marne, where they would have been of service to the Germans; it had held the seige train of 16-inch guns in front of it, when they were needed for the reduction of the Antwerp forts; and it had blocked one main route into France throughout all the period of Von Kluck's advance. In view of these facts it would seem as if one permanent fortress, at least, had justified its construction and the decision to hold it.

II. The Western Trenches, 1915

During the rapid retreat of the French and English armies to the Marne, the battle of the Marne itself, and the no less rapid German retreat to the line of the Aisne, there was little or no attempt at field fortification of any kind. The period of trench warfare proper began in the late Fall of 1914; it lasted almost without intermission until the Spring of 1918. The trench systems on both sides reached their maximum complexity and strength on the British front, and on the western half of the French front. This local development was due to certain favorable natural conditions; climate and soil being the principal factors which incited and aided deep trenching and mining.

From a purely military standpoint, this curious overdevelopment of position warfare is of course an entirely abnormal feature, and there is a tendency today to treat of it as a very exceptional phase of modern war. This attitude is influenced, naturally, by the fact that the American contribution to the war was very effective, that it was utilized during a period of successful open warfare, and that our losses were not heavy enough to cause any popular outcry or political demonstration. That at-b [illegible] course, clearly correct, if we could regard a [illegible] a phenomenon entirely isolated from the world's [illegible] But if we consider it more broadly, certain questions arise and some doubts are cast on the entirely exceptional character of the events of 1915 to 1917. It is at least possible that we have come to a turning point, because of our political and industrial development, and that hereafter war will take new forms. It is in any case certain that whenever we have to deal with a conflict between two great industrial powers, both under democratic government, carried out by conscript armies in highly cultivated regions—the tendencies will all be in favor of position warfare.

The question above posed is not merely a matter of theoretical interest in the present connection, for upon the answer to it will depend whether or not concrete is to be considered, in its application to field fortification, purely from the historical standpoint. For it was during this long period of position warfare, beginning in the Winter of 1914-1915, that we find the first use of concrete in temporary or field works. None of the Regulations in use at the outbreak of the war had suggested or authorized such use of concrete—none of them had even imagined the possibility of such use.

The first official mention of concrete, on either side, appears in the German instructions of June, 1915, covering new points in field fortification based on the experience of the war to that date. Here two types of concrete structures are suggested, in somewhat casual fashion, one for light troop shelters in the firing line and one as a heavy protection for machine guns. The two types are of interest, since they throw light on the order in which different concrete designs were developed.

The infantry shelter is suggested with a cover of ½ to 1 metre of plain concrete laid on a bed of rails or on planks; but the instruction adds that by using iron mesh or nails there will be an appreciable gain in strength. In the second type, that to shelter a pair of machine guns and their crews, the idea of reinforcement is somewhat more pronounced, but has not yet taken definite form. The roof of the emplacement is to be of concrete laid on a double layer of steel railroad sleepers; and round rods are first mentioned as reinforcing. In these instructions the concrete is specified as either 1 cement, 2 sand, 5 gravel; or 1 cement, 3 sand, 6 broken stone.

Following closely in point of time, but far in advance as regards detail, are French notes on the use of plain and reinforced concrete, the series bearing dates from June 27 to August 10, 1915, followed by the Instructions on Fieldworks of Dec. 21, 1915. As compared with the German instructions of somewhat earlier date the French have three points of special interest. First, by implication rather than by command they limit the use of concrete to machine gun emplacements; second, they suggest and permit the use of slag cement in place of portland; third, they give detailed orders regarding the reinforcing. All three of these points of difference are to be explained by a fact brought out in an earlier article of this series: the French coal scarcity was making it more and more difficult to secure cement, and particularly portland cement; and it was more and more necessary to economize in its use. The reinforcing for arches and roofs is to be preferably of ⅜ inch round bars, set in uniform grills vertically 6 inches apart and the grill squares being 4 inches on a side. For walls exposed to direct fire a more complicated pattern is suggested. It is strongly suggested that several beds of steel rails or beams be placed in the mass of arches and flat roofs. The concrete mixture specified, whether slag or portland cement be used, was placed at 400 kilograms cement, 0.3 cu. metre sand, 0.9 cu. metre gravel or stone. This gives a mortar rich enough in cement, but a final concrete with rather too much stone for its mortar, under ordinary field conditions as to selection and mixing. The point will be recurred to later.

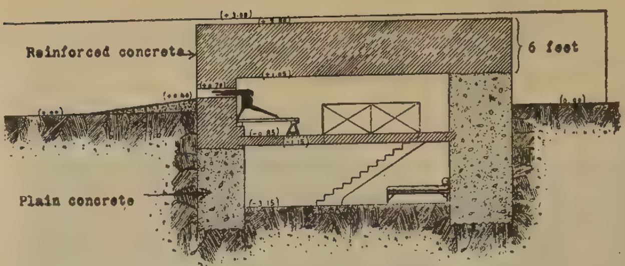


Fig. 5—French Machine-Gun Shelter, 1915.
Plain and reinforced concrete.

Calcium Chloride in Concrete

The United States Bureau of Standards has made some investigations of the use of calcium chloride as an accelerator of the strength of portland cement mixtures. In a series of tests in which a four per cent solution of commercial calcium chloride was used for gaging water it was found that the strength of the accelerated and plain concrete was about the same at the age of three years. This is the longest period for which tests were run.

The Bureau representatives reached the opinion that the merit of calcium chloride is not so much in lowering the freezing point as in reducing the time of hardening for the concrete. That is, cement mixed with a four per cent solution will obtain its initial set in approximately half the time required for plain concrete, and if the materials have been heated set will have taken place, generally, before there is any danger of freezing. In order to reduce the freezing point materially, a considerable amount of the calcium chloride would have to be used and so hasten the set as to make the concrete difficult to handle and would also be more active as a corrosive agent.

The Bureau does not recommend the use of calcium chloride in reinforced concrete work which is to be exposed to extreme moisture or in thin sections where the steel is close to the surface. In heavy construction where the rods are well embedded and where special care is taken to prevent voids or pockets around the steel, it is believed there would be but little danger of corrosion, using the four per cent strength solution.

Patch Ship in Mid-Ocean

An interesting job of patching the hull of a steel ship in mid-ocean was done by the crew on the Danish tank bark, Astrid, after hitting an iceberg. The damaged plate was replaced by a patch of wood and concrete. The hole was tightened by covering with planks, the spaces between the planks being filled with oakum so that the concrete would not flow out. Then a case was made which was filled with a mixture consisting of about 150 kilos of cement (330 lbs.), 200 kilos of sand (440 lbs.), and 75 kilos of coal (165 lbs.). The following day the concrete proved to be so strong that it was able to withstand the pressure of the sea, and the vessel was considered tight so that it could proceed on its way to New York. Concrete is indebted for this information to the managing director for Det Danske Petroleums-Aktieselskab, Copenhagen, Denmark.

Concrete News From Germany

(Continued from page 158)

wood. Bolts and spikes are fastened in the cushions just in the ordinary way and are claimed to hold better than in best oak ties since cement and iron have a comman co-efficient of expansion. A view of a cross section of the Asbeston tie is shown. The Asbeston mass makes a monolithic joint with the concrete at the faces of contact. Official tests with loads up to 28 tons have resulted neither in cracks nor in deformation and should other requirements also be met there can be little doubt that the Asbeston tie may solve the concrete railroad tie problem. This solution, it will be recalled, has so far been frustrated by the difficulty in the way of providing satisfactory means and methods of fastening rails to the ties. A drawback of this tie is its heavy weight which is from 220 to 280 kilogrammes (484-616 lbs.) or three to five times the weight of iron and wooden ties, respectively. This drawback in higher labor costs for laying and replacing is to a certain extent offset by the advantage gained in the lessening of wear and tear of rails, rolling stock, etc., as the weight of the tie will impart a firmer hold to the upper structure of the permanent way. The length of the tie, from a statical point of view, should be slightly above 7 ft.

Concrete and Steel Water Pipes

The oxy-acetylene welding process is steadily gaining ground and has now also been introduced in the production of huge reinforced concrete water pipes in Switzerland. Formerly, iron or steel piping had been used, but proved a rather costly affair. An attempt has now been made to employ light steel tubing with a covering of concrete. These steel tubes were provided with exterior radial ribs of steel welded onto the shell across the entire length of the pipe about 1 in. apart while the inside of the shell has the reinforcing ribs running longitudinally. The spaces thus formed by shell and ribs were filled up with concrete and the surfaces smoothed down. It is claimed that such pipes are equal in strength to steel pipes while their production costs are lower.

Concrete Tanks for Molasses

Concrete tanks and vats are hardly suited for storing molasses, says a writer in the *Chemiker Zeitung*. The lime combines with the suger to sucrate of lime and the silicate of alumina likewise separates so that disintegration of the surface takes place after a time. Protective coatings are stated to be on the whole of little avail. A better remedy and one which is claimed to have given satisfactory results is to use a portland cement poor in lime with an addition of trass. The amount of the latter depends on the aggregate but in no case should the trass be regarded to serve as a substitute for cement.

Slag Cement

Slag cement is generally produced by heating mixtures containing lime and slag or by adding lime to the hot slag. In the latter case, the mixture may be heated in an electric furnace though the danger of the lime coming into contact with the carbon electrode constitutes a great drawback to this process as the carbide thus produced renders the cement unserviceable. A new process has just been patented in Germany by which this drawback is claimed to have been eliminated. By the new process, the cement is produced from hot slag by the direct smelting of the latter together with the lime in the electric furnaces without any previous mixing of the two bodies. In order to prevent the formation of carbide, the lime is allowed to melt down from the surface of the bath. This precludes the possibility of the lime coming into contact with the electrode at a temperature where the formation of carbide takes place while the resulting silicates do not disturb the formation of cement. After having cooled down, the cement thus produced decomposes into a fine product provided due care has been taken to prevent granulation. It is claimed that all kinds of slag are suited for this process.

Reinforced Concrete Resistance to Explosives

The terrible catastrophe at the Oppau works of the Badische Anilin und Sodafabriken has been widely discussed in all its deails by the daily press. One of the questions that has been ventilated dealt with the possibility of erecting explosive-proof buildings for which some contemporaries were inclined to give the preference to brick work as against concrete. That this view is fallacious, is conclusively shown by an article published in a Dutch contemporary, the *Centraalblad der Bouwbedrijven,* where P. W. Sharroo—a well know expert in the explosives line—elaborates upon the superiority of reinforced concrete in this respect. The author cites numerous instances of the war and pre-war period where brick work and ordinary concrete structures not only failed to withstand the enormous atmospheric pressure incident to explosions but by breaking up into big blocks which were hurled broadcast over the territory surrounding the place of the explosion were the causes of many terrible disasters. It is just this breaking up into big lumps that is mostly responsible for damages and injuries and it is here that the advantage of reinforced concrete comes in. The gas pressure in tending to burst the walls exerts a tensile stress upon the concrete which is taken up by the reinforcement within. Even where the walls prove too weak to withstand the explosion, the reinforcement will act like a cushion so that the concrete will break up into many small lumps less likely to have dangerous effects. In substantiation of his claims the author cites instances. The further advantages of reinforced concrete buildings and structures touched upon in the course of the article are of a more general nature and as such do not bring anything new to American concrete men.

* * *

In an office building erected in 1919, whose ceilings were made of reinforced concrete with a layer of xylolite covered by linoleum, the floor began to warp to a steadily increasing extent. Investigations, says R. Grun, in *Zement,* showed that the reinforcement was covered by a layer of rust measuring approximately 3/8 in. The author holds that the rusting of the reinforcement was caused by the soluble magnesium chloride originating from the xylolite penetrating the concrete and calls attention to the necessity of remedying this drawback of the xylolite as well as protecting the concrete with a view to obviate similar occurrences.

* * *

According to a writer in the *Chemiker Zeitung,* concrete vats should be used for electrolysis only if the electrolytic liquid does not react upon the lime. The latter is, however, generally the case as highly diluted acids are mostly used for electrolysis. Vats should therefore be protected by a lining of acid-proof slabs.

Our Foreign Contemporaries

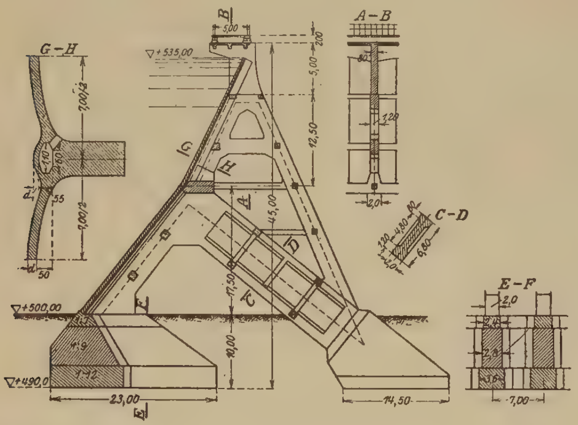
A Review

By E. Lee Heidenreich

Simplified Concrete Dam Construction

Der Bauingenieur in an article by Dr. Engr. Emperger of Vienna, gives some details of Dr. Engr. Rosson's design for the Hasloch dam, which contains some interesting new features. The dam consists of a framework of reinforced concrete bents in which the footings are separated so as to save concrete by locating them according to the resultants of compression forces.

These bents are on the water side covered by arches between the bents so as to avoid the tension stresses which naturally would result over supports, if the usual flat surfaces were used. The sketch shows the general design, and section G-H a cut through the dam surface. Expansion joints are arranged by means of twin frames and alternation of the arch sections across them. While this system has not been much tried, it has a 15% economical advantage over any of the modern constructions (Ambursen, etc.), and will therefore probably be subject to several improvements as to its details.



New Dam Design

Waste in Tearing Up Streets

Tonindustrizeitung calls attention to the appalling waste of labor in removing parts of the concrete base for repairs or changes in pipes or conduits in city streets.

The base of the asphalt paving of the streets of Berlin consists of a 10 in. layer of concrete. Whenever a change or repair is required there is a chance to observe the waste of human labor in removing a part of this base. A one hundred-weight of concrete requires the hard work of five men; a cigaret smoking individual holds by means of a long safe handle a steel wedge on which two able bodied heroes apply each in turn a heavy sledge in measured rhythm. Why not use carborundum wheels to cut the concrete in small square or strips of such width and length that they can be used for steps or sills?

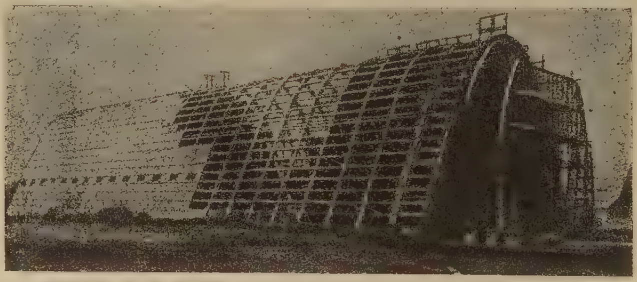
By use of the proper grinding machinery, the surfaces could be made acceptable for building purposes.

At present the laboriously gained concrete blocks are broken by means of sledge hammers into smaller pieces so as to be used as aggregates for concrete again. We see the same thing in our American cities everywhere. and with the advent of pneumatic hammers and drills some of the work of waste should be saved. The time will come, when the concrete sub-base either is laid in unit pieces, that may be removed more readily, or conduits built for pipes, with shelves or space available for rent to corporations or individuals, and these conduits will be accessible on their own level without in any way disturbing the street surface. The writer suggested this in an article in *Chicago Daily News* in 1891, and at that time was encouraged by the elder Mayor Carter Harrison, but nothing was done to utilize the scheme. (The idea was again developed and urged in this magazine ten years ago.)

A Daring Hangar Construction

(After Gerhard Neumann, Gyor in *Benton und Eisen*)

Le Genie Civils describes a number of hangar designs, among them one recently built at Montebourg. The structural frame consists of a series of A-frames, placed in pairs 21 ft. on centers and surmounted by three-hinged parabolic arches. The A-frames are 60 ft. high to the center of the lower hinge, and the top of the arch is 135 ft. above the ground. The hangar is 100 ft. wide, 500 ft. long and 135 ft. high. The A-frame outside struts are 16 in. x 20 in. with six 9/16 in. round reinforcing rods. The arch ribs are 16 in. x 35 in. with six ¾ in. rods at top and the same reinforcement at bottom of the chord, tied every 12 in. with ¼ in. round wire. The entire hangar is covered with cement tiles 64 in. x 84 in. and only 7/16 in. thick reinforced by a wire mesh. Each plate is held on a rafter by means of a cross rib 16½ in. from one end of the plate. The plate has two 2 in. x 2 in. ribs running lengthways of the slab, also properly reinforced. The rafters are constructed in U section with 2⅜ in thick body, 12 in. x 16 in. over all. The end wall of the hangar is built independently of the main structure so as to prevent the transmission of wind pressure to the main structure.



Reinforced Concrete Hanger Under Construction

Floating Foundations for Warehouses

During 1911-1913 extensive storage warehouses were built for the department of customs of the government of Uruguay, at Montevideo, according to Eisenmenger in *Der Bauingenieur*. Owing to a scarcity of funds and to avoid expensive waterproofing of a basement, the buildings were built above water level. There were six warehouses 110 ft. x 420 ft., two stories high and two buildings 100 ft. x 360 ft., one story. The ribbed mat foundation was calculated to withstand the soil pressure resulting from second and third story live loads of 500 lbs.

per sq. ft. The first floor load is resting on the sand filling above the slab and helps to reduce its dimensions by counteracting the updrift or pressure from below on the foundation slab between ribs.

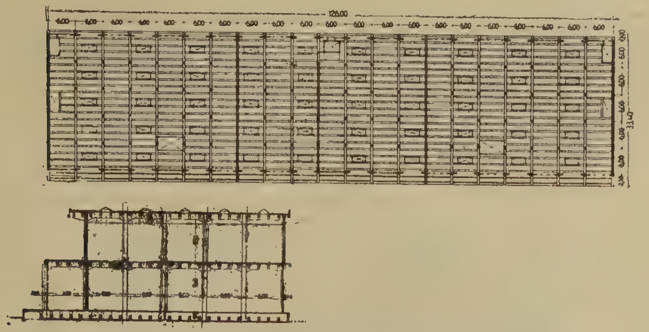
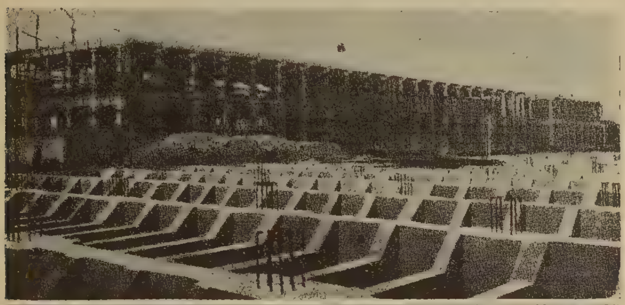


Fig. 1—Plan and Section of Large Building Erected on Ribbed Mat Foundation



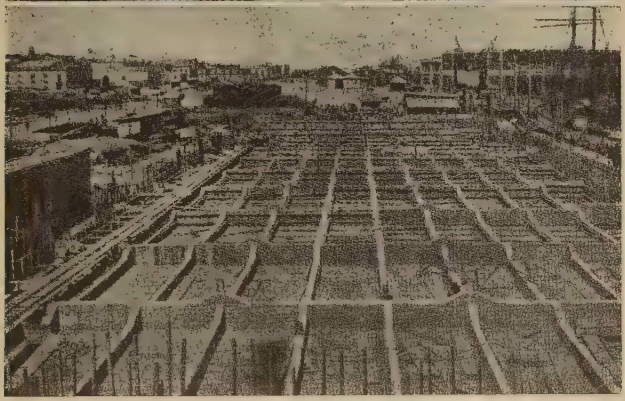


Fig. 2—Construction Under Way—Ribbed Mat Foundation in Foreground

Fig. 3—Ribbed Slab of the Smaller Building

For low lying cities with poor soil for foundation purposes or for swamp locations, such design may well be considered, as far more economical than caissons or piling, where the basement can be sacrificed.

Vegetable Oils in Concrete Tanks

The use of reinforced concrete for reservoirs in oil storage has in the United States been limited chiefly to storage of mineral oils and distillates.

Tonindustrizeitung advises us that Margalit has been placed on the market as a successful lining for tanks where vegetable and animal oils are to be stored.

Margalit is an invention of Professor Dr. Marcusson, Berlin, and is an artificial pitch produced by condensation of formaldehyde with phenol, which is placed on the concrete like a paint and quickly dries. For concentrated mineral oils, such as tetralin (manufactured from naphtaline and hydrogen) the former German marine used to line the storage tanks, partly with glazed tiles, partly by means of rivited or soldered sheet iron or tin surfaces.

Gasoline reservoirs are in the United States successfully protected by careful mixing of the concrete, careful manipulation of the surface and a lining of a shellac mixture of a suitable consistency.

German Concrete Oil Storage

Dr. A. Guttmann, Dusseldorf, describes in *Tonindustrizeitung,* a recently patented concrete oil storage system, consisting in filling an annular space between an inner and an outer concrete tank with water having a higher hydrostatic pressure than the oil contained in the inner tank.

Adding a little chloride of lime to the concrete, so as to permit the latter to absorb moisture so as to keep it as it were water-soaked, will cause the water pressure to prevent any oil to percolate from the oil tank to the annular space.

As water and oil do not mix and the former is heavier than the latter, the oil is kept effectively from penetrating outward, and by giving the concrete the proper density, the water is prevented from getting through to the oil tank. However, any water penetrating, would simply sink to the bottom of the oil from where it readily could be removed by sewer or syphon.

More About Concrete Freight Cars

Prof. Dr. Engineer Klenlogel of Darmstadt, describes in *Tonindustrizeitung* a number of collision tests made by the Fuchs Mfg. Co., car shops, Heidelberg, on reinforced concrete freight cars.

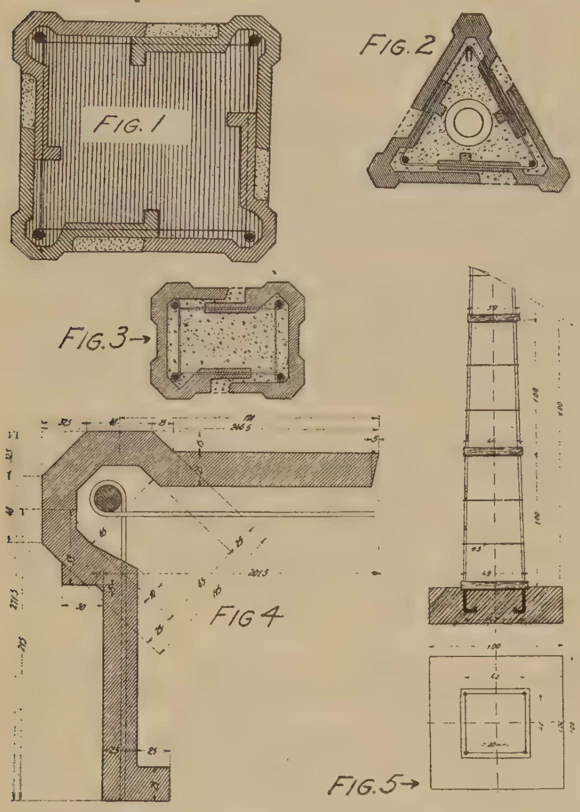
One-third of the length of a reinforced concrete car frame was built into a railroad bumper arrangement, and after a series of observations under collisions was tested to destruction. On the basis of the information gained, the 15 ton gondola car was built and put into service. In May, 1920, a number of tests were made in the terminals of Heidelberg, with speeds up to 21 kilometers (9 miles) an hour, both brake tests on one rail, and collisions with steel cars. To start with, empty cars were used—later the same cars loaded with 17 tons of iron ore. All parts of the car frame remained intact and unharmed in any way, and not even the slightest crack was observed.

Emperger's Concrete Transmission Towers

Dr. Emperger, whose designs and inventions are crowding the pages of technical literature in reinforced concrete, is again before the engineering world with an important innovation.

The increasing demand for electrical power transmission has heretofore been hampered by the cost and difficulty of transportation of transmission poles and towers. These have been built of steel or reinforced concrete, the latter in one length each, necessitating manufacture in situ or a complicated method of moving it from point of manufacture to point of use.

The Emperger mast, according to Dr. Richard Rossin in *Beton u. Eisen,* consists of step-like series of precast molds, 2, 3 or 4 to a section, see Figs. 1, 2, 3, and 4, which serve as forms, either for the entire cross section of the mast, or in larger structures as forms for each of two or more legs or corners. The hollow core may either be filled with a leaner concrete or as shown in Fig. 2, left with an inner core, which again may be filled with sand. Fig. 5 shows the steel reinforcement erected to receive the corner forms, and hooked into the foundation slab. Fig. 1 shows how the cross section of the mast may be increased by sliding the forms outward. The precast concrete blocks are manufactured like other building blocks, either at a centrally located plant or at an improvised shop near the site of erection.



Details of Precast Sections of Transmission Towers

Concrete Drinking Fountain

The reinforced concrete drinking fountain pictured in the accompanying illustration was made to take the place of an old boiler-plate fountain that had rusted out. It gave satisfaction and John H. Miller & Sons, Clinton, Conn., made several which have been in use for several years. They are poured in home-made wooden molds fitted with brass pipes for feed and overflow, and reinforced. In places where there are still enough horses to make the effort worth while such drinking fountains would admit of even more ornate treatment.

Reinforced Concrete Drinking Fountain

Old Cement Mortar Water Conduit

An interesting example of a cement mortar water conduit constructed in the year 1855 or 1856 is found in the City of Newark, Ohio. It was built to carry spring water to a distillery, a distance of a mile. It is 2 in. in diameter, with a shell about 2 in. thick.

It was built in place in the trench by plastering the mortar around a cylindrical rod which was twisted and pulled forward as the work progressed.

Piece of Cement Mortar Water Conduit Built About 1855

Information as to the date and methods of construction has been gathered from old residents who witnessed the work through the courtesy of Mayor Samuel S. Orr. The impression is that natural cement was used in the proportion of one part of cement to three parts of coarse sand.

How Many Courses of Block in a Day?

A subscriber asks how many courses of block can safely be laid up in a day. The answer depends on many things—the kind of mortar used, lime or cement, the temperature when the job is done, the kind of cement (some brands set up faster than others) and so on. The Portland Cement Association reports a record of 22 courses of silo block 5 x 6 x 12 being laid in one day in a mortar composed of one part portland cement and three parts sand and an addition of 10% by volume of hydrated lime. This was done in warm weather. A. J. R. Curtis, of the Association, expresses the belief that 15 to 18 courses could be laid in a cement mortar in anything but cold weather when the temperature is low and the block are heated it being possible to approximate the number of courses that are laid in warm weather.

"The percentage of absorption will also have a bearing on the speed with which the mortar will set up," says Mr. Curtis. "We have a record of a case where very dense concrete brick were being laid on a job in Toledo in which the brick floated in the mortar when about 10 courses had been put up. The brick had an absorption of less than 1%." Such brick are *too dense* for proper suction.

Small Units in House Building

Window and Door Frames and Chimneys—Part 4

By A. J. R. Curtis
Chicago

All of the commercial systems for the manufacture of concrete block and building tile provide units especially designed for use around the window and door openings. These consist simply of standard full and half length block, in one end of which provision is made to receive the ordinary box or plank frames.

In the self-contained air space type of block and in the building tile one corner is notched or cored to receive the frames; in some of the two-piece block systems the jamb block is merely a notched corner block. In other two-piece systems the inner blocks are shortened at the opening, producing the same effect as notching. Jamb blocks of the air space type are shown in Figs. 43, 45 and 47, and building tilein Fig. 46. Jamb blocks to receive plank frames are usually indented or notched to a depth of 1½ in. to 2 in., while those to receive box frames have corresponding recesses 3½ in. deep, in which the frames may be easily adjusted as desired.

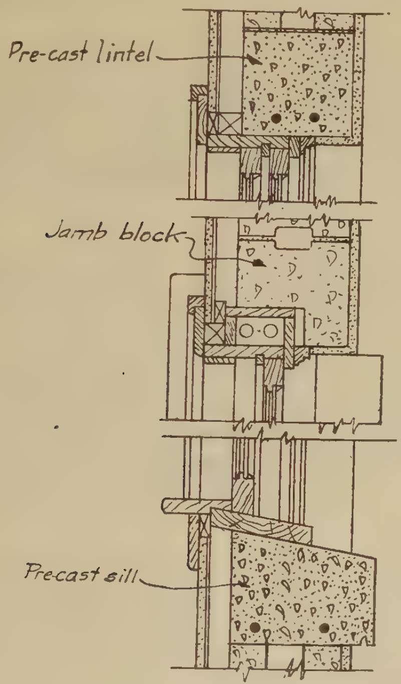


Fig. 43—Window Detail Showing Use of Jamb Block to Accommodate Box Frames

Fig. 44—Porch and Other Lintels of Large Size and Considerable Weight are Frequently Cast in Place

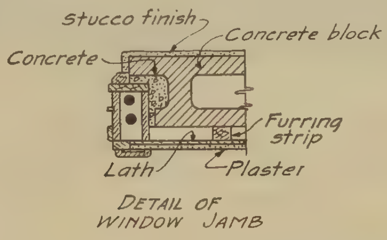


Fig. 45—Box Frame Inserted in Space Provided by Cutting Away Inside Portions of Block, Filling Surrounding Space with Mortar. "Jamb Blocks" are Usually Provided to Fit Exactly the Box or Plank Frames Used

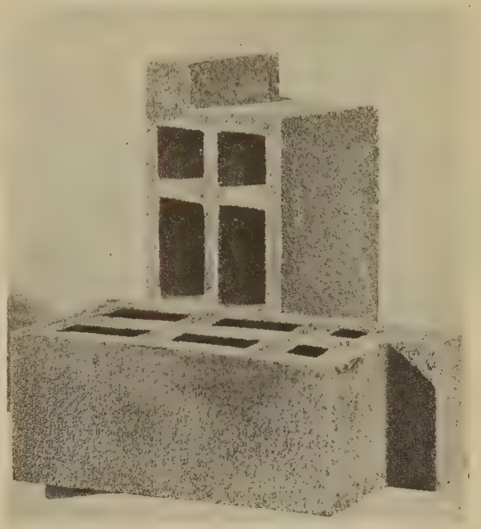


Fig. 46—Example of Concrete Jamb Blocks. The Units Shown are Erickson Building Tile

Special jamb block are easily produced by means of simple inserts in the molds, where frames of unusual size or design are to be used.

The Chimney

Concrete chimney block have proven beyond question the most practical units for residence chimneys in use at the present time. Carefully laid, in a rich portland cement mortar, concrete chimney block are not only to be recommended without clay flue tile for the chimneys of dwellings, but they cost less to erect than any other kind. When city ordinance requirements bend over backwards and require an additional clay flue lining, the same as always required for brick, the concrete block chimney is still the most economical.

The two general types of concrete chimney block in most common use are illustrated in Figs. 49 and 50. The former illustration is typical of the rectangular block which usually have walls approximately 3 in. thick, the upepr and lower surfaces of which are roughened to give them a good grip on the mortar. These block usually contain two complete reinforcing bands made of ¼-in. round rods placed on the center lines near the bottom and the top. The sizes of these block generally conform to available sizes of clay flue lining.

The Multiplex block, shown in Fig. 50, is perhaps the most widely used of any concrete chimney block. It is easily distinguished by its particular shape—consist-

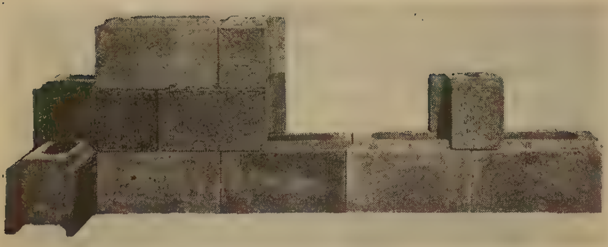


Fig. 47—Method of Laying up the Block for a Window Opening is Shown by This Demonstration Picture, Using the Acme Block, a Recently Developed Product

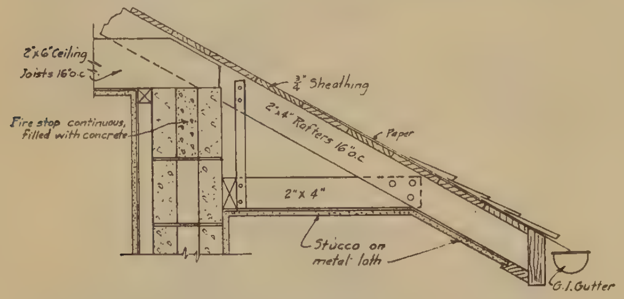


Fig. 48—The Top Course of Block Should be Made Solid as Shown to Prevent Any Possibility of Water Getting in, in the Event of a Leaky Roof. The Roof Framing Should Preferably be Anchored to the Block Wall by Means of Bolts Embedded in the Top Course at Intervals of 4 or 5 ft.

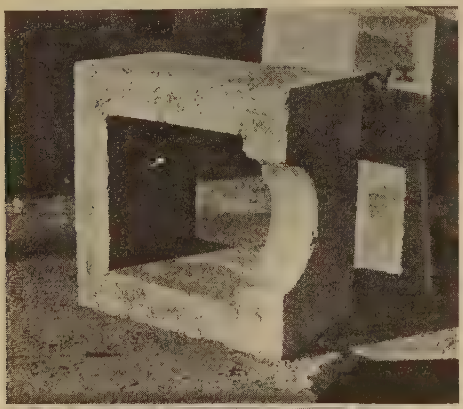


Fig. 49—One of the Standard Types of Concrete Chimney Blocks, Showing Half of a Smoke Pipe Outlet. These Block are Reinforced and are Laid in Rich Cement Mortar with Flush Joints

Fig. 50—Stock of Multiplex Chimney Blocks Showing the Characteristic Design with the Circular Inner Wall and Rectangular Outer Wall

Some cities require an inside flue lining. With or without flue lining block of this general type produce cheaper and better chimneys than most other masonry materials.

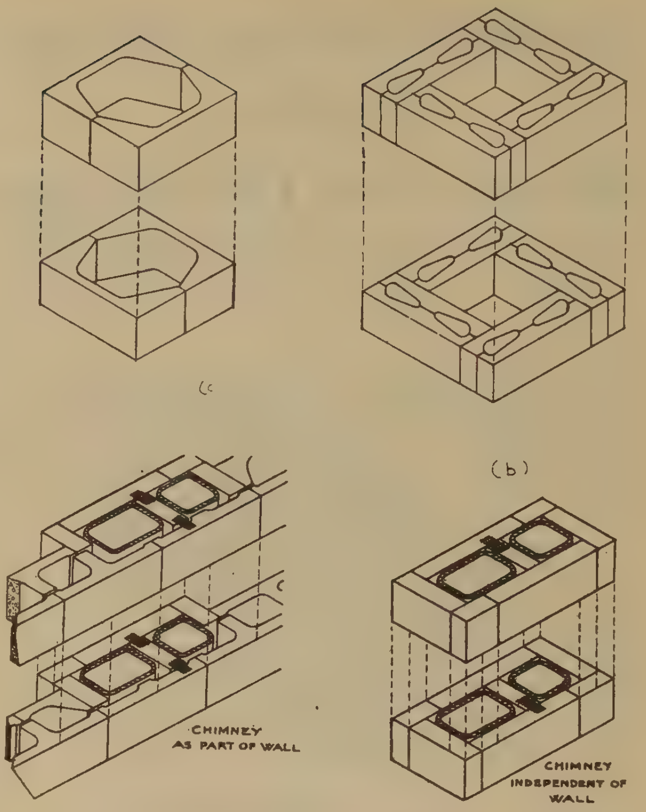


Fig. 51—Chimney Construction for Special and Two-Piece System Blocks

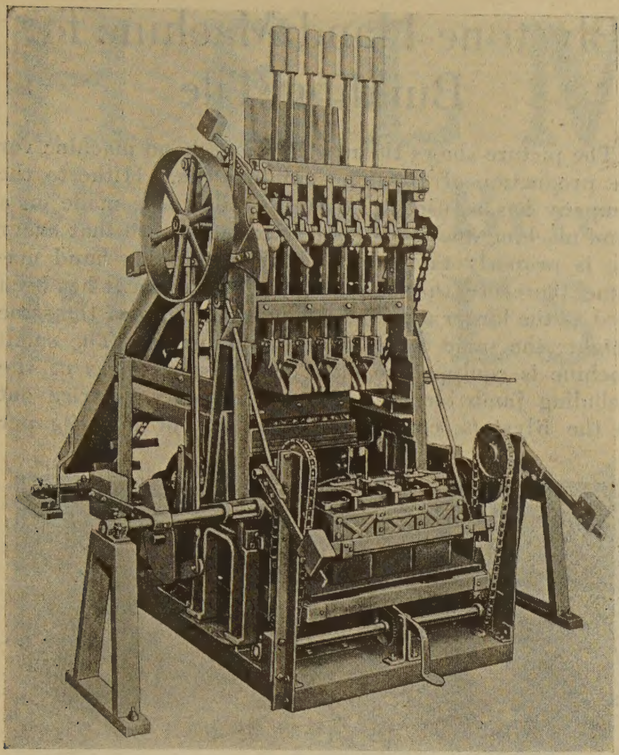
(a) is used for small chimneys (24 in. x 24 in., outside dimensions) made by the Hydro-Stone process; (b) is a 16-in. x 16-in. chimney made with Hydro-Stone partition block; (c) illustrates a common method of building up chimneys in double block walls, and (d) shows a double chimney of double wall or slab block.

ing of an outside square joined to an inner circle, with corners between square and circle open. This block is well adapted to residence chimney work when made of good quality concrete, for although the individual wall thicknesses are about 2 in., the top and bottom surfaces are grooved to key the mortar, and when properly laid they produce satisfactory results. Frequently the four corner air spaces are poured full of concrete as the chimney goes up, producing additional keying of the blocks.

In the two-piece block systems such as Hydro-Stone, the chimneys are usually constructed as shown in Fig. 51. The block shown at (d) are 4 in. thick and when laid as shown, produce a very strong and rigid construction. Chimneys made in this manner are usually lined with clay flue lining. Where such a chimney is located on an exterior wall of a dwelling, the inner wall blocks are usually omitted and the outer wall blocks made to serve also as the wall of the chimney. The remaining walls are built up of 4-in. slabs and tied into the building wall by breaking joint at the junction with the inner wall block.

Occasionally the chimney is constructed of specially cast units and, in such cases, it usually becomes an especially ornamental feature of the house.

Mr. Curtis' next article considers Roofs for Concrete Houses —in May issue.



Ideal Automatic Building Tile Machine

Ideal Tile Machine

The Ideal Concrete Machinery Co. has put on the market an automatic building tile machine. Concrete is fed into the conveyor at the back, and the operators at the front insert empty pallets and carry them away filled with tile. The arrangement of the machine is such that while an empty pallet is being exchanged for a full one, the machine is making the next batch of three tile.

The design of the machine permits tile of many dimensions to be made without the necessity of additional pallets. It is only necessary to make the changes in the mold box and tamp feet. The 5 x 8 x 12- unit is considered the standard size. Tile 5 x 4 x 12 and 5 x 12 x 12 are also frequently used and can be made readily.

The conveyor at the back is a part of the machine. It receives the material direct from the mixer and conveys it into a material hopper. The feeding box which slides below the material hopper carries the concrete over the mold box where it is packed into place by the tampers. The feed box is then withdrawn, scraping off the excess material and carrying this back under the material hopper, ready for the next charge. After the withdrawal of the feed box, the mold box swings into delivery position, bringing the bottom of the tile into contact with a wood pallet which is placed on a balanced table. No cast iron stripper pallets are used. The machine then strips the three tile onto the pallet and at the same time pushes the pallet table down so that the tile are clear of the mold box, after which the mold box immediately swings back into place, the feed box comes forward and the machine starts on its next cycle. The full pallet is removed and an empty one substituted while the machine is tamping the next set of tile. At no time is it necessary to stop the machine, nor is there any pause in its operation while the tile are being removed. Tile are made with the cores vertical and are delivered with the thick side of the tile down, thus increasing the amount of water which may be used in the mix.

The machine is unusually rigid and is set on a flat cast iron bed plate, upon which all parts are mounted.

A New Gasoline Shovel

The Bucyrus Company's 30-B gasoline shovel has no engines, motors, shafts, chains or gears on the boom and yet according to the manufacturers, digging power greater than a steam shovel of the same size.

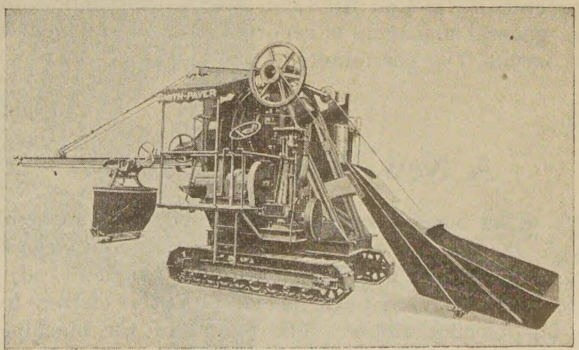
Before being put on the market, this shovel was used for six months in overcasting and loading dump cars in sticky clay, grading for a concrete road where the cut averaged five inches in old macadam, and for stripping a stone quarry and loading trucks in stiff hardpan containing many boulders.

Bucyrus 30 B Gasoline Shovel at Work

It is simpler than other types of gasoline shovels and has fewer parts. The gasoline engine was designed especially for this shovel from specifications offered by the Bucyrus engineers. It is entirely enclosed. It is a four cylinder, slow speed type and will develop 55 h.p. at a speed of 400 r.p.m. The shovel carries a 1-yd. dipper. This machine may be equipped as a dragline excavator, a crane or a clamshell machine with simple changes which may be made in the field.

Caterpillar Traction Pavers

The T. L. Smith Co., Milwaukee, has produced a new full caterpillar type paving mixer. The treads are of electric heat treated steel castings only 8 in. wide and very closely fitted together. This feature reduced the "jaw crusher" action noticeable in treads of larger pitch,



Smith Full Caterpillar Mixer

the interstices of which open up more widely at the bend. The small pitch also gives the mixes an easier movement.

A feature of these paving mixers is the new cross-dump bucket. The doors of this bucket open crossways instead of lengthways. This design is intended to give quicker discharges.

Brock Automatic Roof Tile Machine

The automatic roof tile machine illustrated has been built for the market by Brock Bros. Manufacturing Co., St. Louis, Mo., producers for a number of years of hand operated machines. The various operations are shown in the diagrammatic illustration.

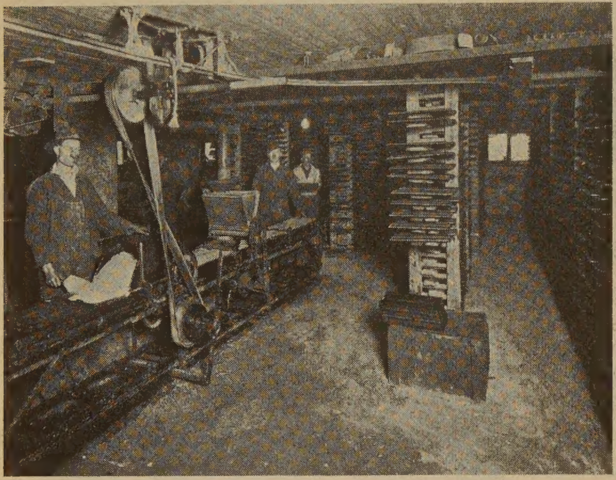
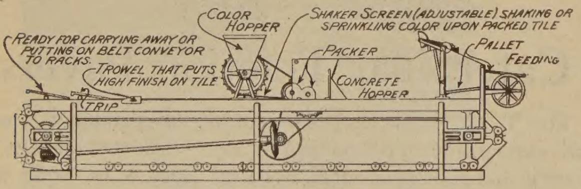


Fig. 1—Brock Automatic Roof Tile Machine In Operation
Fig. 2—Diagram of Machine Parts and Operations

The machine has two speeds, seven or ten tile a minute, with three operators—one to mix material and deliver pallets, one to feed and take care of machine and one to remove tile from machine.


COLOR HOPPER
SHAKER SCREEN (ADJUSTABLE) SHAKING OR SPRINKLING COLOR UPON PACKED TILE
READY FOR CARRYING AWAY OR PUTTING ON BELT CONVEYOR TO RACKS.
TROWEL THAT PUTS HIGH FINISH ON TILE
PACKER
PALLET FEEDING
CONCRETE HOPPER
TRIP

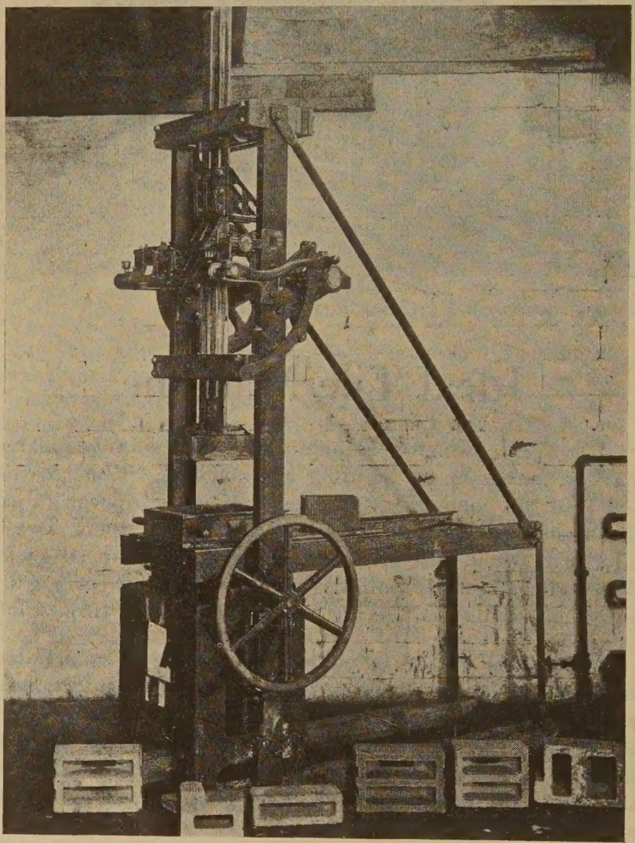
The machine is operated by a two h. p. motor. One of the machines has been in use in the plant of the Roofcrete Mfg. Co., St. Louis, for a year and J. Wilson, general manager, is reported as well satisfied with the output, 7½ per minute.

A New Bench Band Saw

A 16 in. bench band saw is now being manufactured by J. D. Wallace & Co., Chicago, Ill., equipped with disc steel wheels, with ball bearings throughout, adjustable table; moving parts enclosed. It is driven by a ½ h.p. electric motor. The height of the machine is 5 ft. 9 in. over all and the floor space required is 15 in. by 29 in. The saw speed is 3150 ft. per minute.

Blystone Hand Machine for Building Tile

The picture shows the new Blystone hand machine for the production of Blystone building tile. Hitherto the company has refused to allow the tile to be made on a hand machine due to its anxiety to make sure that every tile is properly tamped. In perfecting this hand machine, therefore, the same tamping arrangement has been used as the larger machine, including a tamp of the same weight; the same cores, pallets and plates. The small machine is equipped to make all different sizes of tile including jamb blocks and has a capacity as tried out on the Blystone company's own floor, of one tile per minute of the 5x8x12, or 5x8x10 sizes or 120 units of the 4x5x12, 5x6x8 or 5x6x8 sizes. Instead of having a loading device the hopper is over the core and the hopper is filled by hand. After the tile is tamped the hopper is pushed back, automatically scraping off the top of the tile and taking care of surplus material. A half revolution of the hand wheel strips the tile up out of the machine ready for removal.



The Blystone Hand-Operated Building Tile Machine

Stucco and Plaster Base

Thin sheets of perforated slate are now on the market to be tacked onto furring strips and onto studding as a base for plaster and stucco. It is offered by the Slate Veneer Co., New York. It is pointed out that it makes a good clinch for the plaster and stucco, gives a smooth, hard surface, enabling the mason to do the work properly, and has the advantage of not rusting, shrinking or swelling.

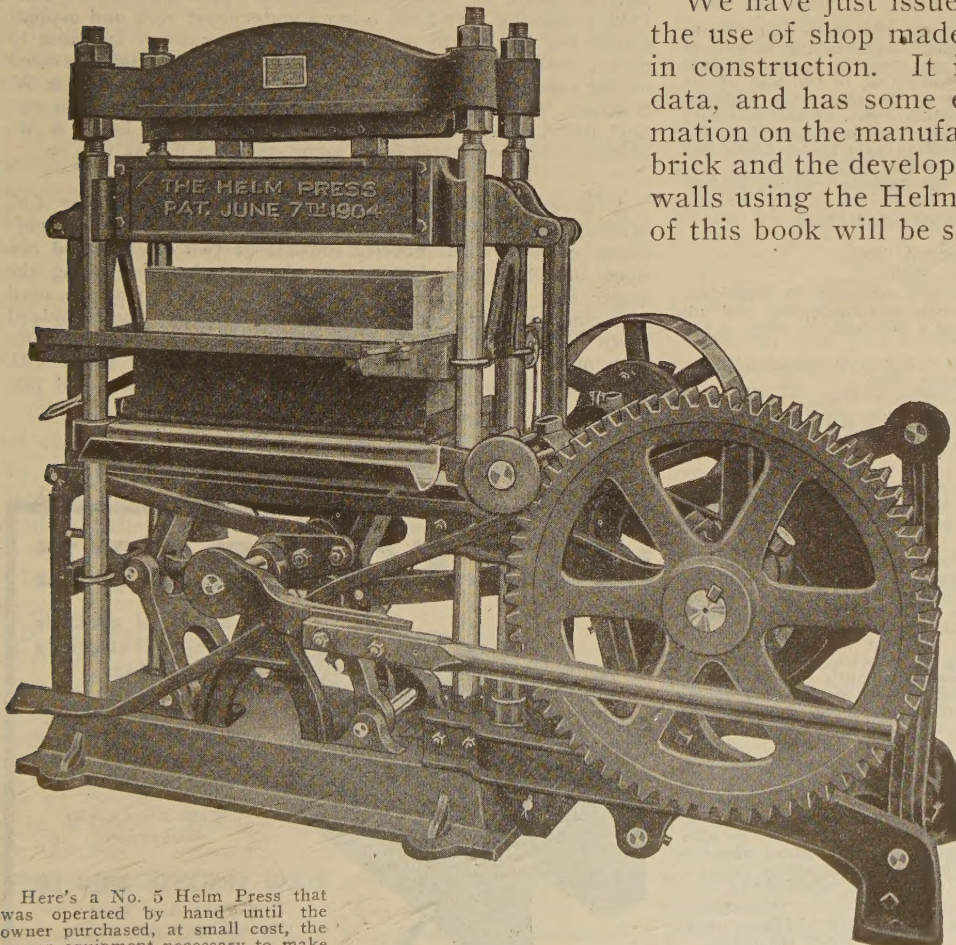
HELM
Block and Brick PRESSES

Never since 1913, has the building outlook been brighter. Building statistics show a regular and remarkable increase in construction activity for the past several months. The demand for building units this Spring is going to be enormous.

Whether your customers want brick or block, you can supply them if you equip your plant with one or more HELM presses. A Helm press is a better investment today than ever before.

The book tells the story

We have just issued a new book discussing the use of shop made concrete building units in construction. It is full of plans and cost data, and has some especially valuable information on the manufacture and use of concrete brick and the development of two piece hollow walls using the Helm dry wall block. A copy of this book will be sent free upon request.



Here's a No. 5 Helm Press that was operated by hand until the owner purchased, at small cost, the power equipment necessary to make it an automatic press.

Tell us what kind of concrete products you want to make and how many you want to turn out per day. Give our Engineering Department an opportunity to help you solve your plant layout problems.

Helm Brick Machine Co.

843 Mitchell St.

Cadillac, - Mich.

Organizations

American Concrete Institute; Secretary, Harvey Whipple, 1807 East Grand Boulevard, Detroit.

American Concrete Pipe Association, M. W. Loving, Secretary, 111 West Washington St., Chicago.

Associated Metal Lath Manufacturers, Edison Bldg., Chicago; Wharton Clay, Commissioner.

Iowa Cement Stave Silo Association; H. E. Kilmer, Secretary, Oskaloosa, Ia.

Mid-West Concrete Products Assn., Frank Whipperman, Secretary-Treasurer, 3045 Fowler Bldg., Omaha, Neb.

National Crushed Stone Assn.; A. P. Sandles, Secretary, 405 Hartman Bldg., Columbus, Ohio.

National Housing Assn.; Lawrence Veiller, Secretary and Director, 105 East 22nd St., N. Y. C.

The National Lime Association; Mather Bldg., Washington, D. C.

National Sand and Gravel Producers' Association; E. Guy Sutton, Secretary, Williamsport, Ind.

The National Concrete Stave Silo Asociation; W. G. Kaiser, Secretary, 111 West Washington St., Chicago.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912.

Of CONCRETE, published monthly at Detroit, Michigan, for April 1, 1922.

State of Michigan, }
County of Wayne, } ss.

Before me, a Notary Public, in and for the State and County aforesaid, personally appeared R. Marshall, who, having been duly sworn according to law, deposes and says that he is the General Manager of CONCRETE, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and, if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in Section 443, Postal Laws and Regulations, printed on the reverse side of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher—Concrete-Cement Age Pub. Co., Detroit, Mich.
President—R. Marshall, Detroit, Mich.
Managing Editor—Harvey Whipple, Detroit, Mich.
General Manager—R. Marshall, Detroit, Mich.

2. That the owners are (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent. or more of the total amount of stock).

Concrete-Cement Age Pub. Co., 1807 E. Grand Blvd., Detroit, Mich.
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F. F. Lincoln, Room 1205, 115 Broadway, New York City.
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R. W. Lesley, Penn Bldg., Philadelphia, Pa.
Edward B. Bruce, Manila, P. I.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities, are: (If there are none, so state). None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest, direct or indirect, in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers, during the six months preceding the date shown above is ——— This information is required from daily publications only.)

R. MARSHALL,
Manager.

Sworn to and subscribed to before me this 28th day of March, 1922.
(Seal.) IONE MICHAEL.
(My commission expires April 9, 1923.)

Products Enterprises Merge

The large plant of the Brooklyn Crozite Brick Corp., which was described in detail in CONCRETE[1] and fifteen concrete products plants which are using the Straub cinder block patent including plants at Wilmington, Del., York, Pa., Lancaster, Pa., Camden, N. J., and so on are affected by the consolidation of the Crozier system and process for manufacturing brick, block, and tile and the Straub system for making block and other units with cinder aggregate and cement. The merger was affected under the direction of E. B. Cadwell & Co., Inc., New York City. Alfred O. Crozier, New York, is president of the new company which will have the title Crozier-Straub, Inc., New York City, and the vice-presidents are F. J. Straub, New Kensington, Pa., and H. O. Pond, of E. B. Cadwell & Co., Inc., New York, formerly mechanical engineer of Westinghouse, Church, Kerr & Co. Secretary and Treasurer of the new company will be Howard Brooks, vice president and treasurer of E. B. Cadwell & Co., Inc. The interest of E. B. Cadwell & Co., Inc., originates from the establishment of the plant of the Brooklyn Crozite Brick Corp., which was built by the Raymond Concrete Pile Co. and E. B. Cadwell & Co., Inc., with an investment of about half a million dollars.

Trade Publications

Par-Lock Plastering—The Vortex Mfg. Co., 178 West 77th St., Cleveland, O. Bulletins announce specifications for Par-Lock plastering, Par-Lock being a waterproof rock and asphalt mastic key applied to concrete and other masonry surfaces to give a good bond for a plaster finish. The material was used on the ceilings of the South Orange Station of the D. L. & W. Railroad, where more than a hundred trains pass over the viaduct daily. The work was done in 1914 and the D. L. & W. reports that the plaster is as sound as when it was put on.

A novelty distributed by Pawling & Harnischfeger Co., Milwaukee, shows how the P. & H. excavator crane is an eight-in-one machine. The novelty consists of two discs placed one upon the other and fastened at the center. By moving the upper disc in a circle the various booms that may be used with the excavator crane appear successively—the standard boom with the dragline bucket, boom with grab bucket, boom with material handling hook, boom with magnet, boom with backfilling scraper, shovel attachment, skimmer scoop and pile driving rig.

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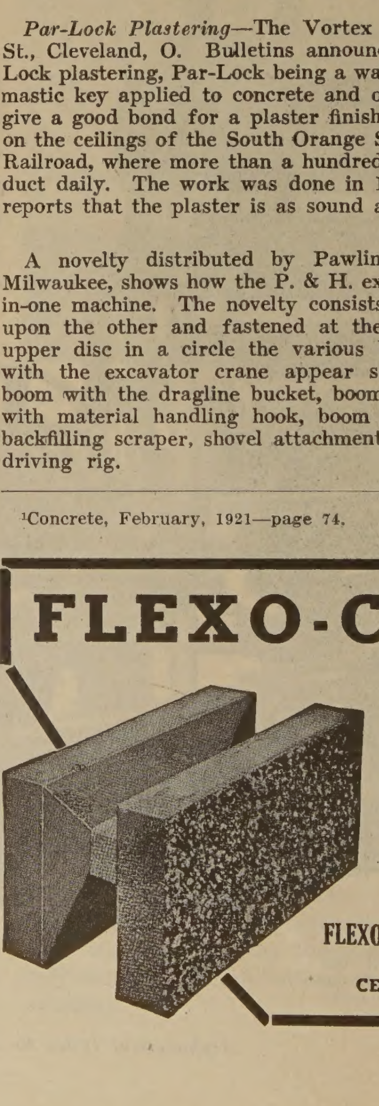
[1] Concrete, February, 1921—page 74.



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